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ADAPTATION OF THE AASHO PAVEMENT DESIGN GUIDES TO OKLAHOMA HIGHWAYS

PROJECT 64-11-3

by

R. L. Janes, Professor of Civil Engineering
S. Y-W Ng, Research Assistant
Oklahoma State University

This Research Conducted Jointly by
OKLAHOMA STATE UNIVERSITY
and
OKLAHOMA DEPARTMENT OF HIGHWAYS
in cooperation with
U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION
BUREAU OF PUBLIC ROADS

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ABSTRACT

Data are reported on physical properties of roadbed structural materials from in-place samples of most of the flexible state highways built in Oklahoma over an 11-year period. Associated traffic volumes, load history and climatic conditions, making a total of seven variables, are reported. These variables are compared to two sets of surface roughness, or serviceability measurements obtained by use of the CHLOE profilometer. It is shown that little significant correlation exists between changes in serviceability index as measured by the CHLOE, and the physical properties and traffic. Similar conclusions have been reached in other states. Of the parameters observed, it appears that road surface roughness is more sensitive to rainfall, traffic volume and road surface thickness than to quality or thickness of basement layers.

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ADAPTATION OF THE AASHO PAVEMENT DESIGN GUIDES TO OKLAHOMA HIGHWAYS

Introduction

The purpose of this investigation has been to study the design of flexible pavements in Oklahoma with emphasis on a number of measurable variables which could be compared to similar variables in the AASHO Road Tests. The pavement performance equations developed from the AASHO Road Tests are generally applicable to situations in which the environmental conditions, road-bed structural materials, and traffic closely simulate those at the road test. It was hoped, however, that with proper and sufficient data relating to conditions prevalent in Oklahoma, the equations could be modified in such a way as to make them useful for Oklahoma conditions as well. At the AASHO Road Test pavements of various thicknesses were built on a single subgrade soil with one material for subbase, one material for base, and one material for the asphalt concrete surfacing. Traffic consisted of about one-million applications of closely controlled loads. Each of the two main loops of the five test loops had constant weight and axle configuration trucks. Conversly Oklahoma highways have a number of different types of subgrades, subbases, and base materials and roads are subjected to Oklahoma rather than Illinois climate and to mixed rather than controlled load applications.

This report is divided into the following chapters:

1. A brief description of the AASHO Road Test.
2. A discussion of the so called "satellite road test program".
3. The specific satellite study for Oklahoma.

4. The experimental design utilized in the Oklahoma test.

5. Sampling procedures and field experiments.

6. An evaluation of pavement performance from PSI differences.

7. Laboratory testing of pavement materials on the selected sections.

8. Traffic Volume.

9. Discussion and Conclusion.

1. DESCRIPTION OF THE AASHO ROAD TEST

General

In the year 1946, immediately after World War II, the AASHO Committee on highway transport held a series of meetings centered around the growing importance of highway transportation, and the technical limitations on the size and weight of the vehicles imposed by existing highways and bridges. There was general agreement that the highways of the nation were being damaged. However, there was a wide range of suggestions as to the cause of the damage. Discussions revealed that there was considerable need for more factual data upon which to establish vehicle size and weight limits, and to provide a basis for overall economy in highway design. Various test plans were formulated, and Road Test One - Md (1) and the WASHO Road Test (2) were carried out. At the time, these tests were considered rather ambitious, but by the early 1950's it was apparent that a more comprehensive test was required and the plans were initiated for what was to become the AASHO Road Test. In 1952, the committee selected the site for the project between Ottawa and La Salle in Illinois. The location for the AASHO test was about 80 miles Southwest of Chicago. The annual precipitation at this site averages about 34 inches of which some 31 inches normally occurs as rain. The area has an average mean summer temperature of 76°F and an average mean winter temperature of 27°F. The average depth of frost penetration is about 28 inches.

The several years of planning and site selection resulted in an unprecedentedly ambitious and expensive project. Financing of the AASHO Road Test was shared by all of the 48 continental states, the Bureau of Public Roads, and with assistance and cooperation from the Department of Defense. A field office was established in 1955, and during the ensuing three years, technical personnel were selected and the test road and facilities contracted for and built. AASHO Road Test Report I (3) contains a complete history of the preparation and planning, the factors considered in selecting the test site, and the organization which directed the project. Traffic was started over the pavements in the fall of 1958, ending in the fall of 1960 after 1,100,000 applications of load. Traffic was continuous during this time except for a few periods of shutdown required for maintenance.

During the period of traffic application numerous tests and evaluations of the pavement, bridges, etc., were conducted. A complete history of the testing procedures may be found in the several volumes of the AASHO test report. In addition, a summary and discussion of the findings presented at a conference held in St. Louis in May of 1962 may be found in Highway Research Board Special Report 73.

Layout of Project

The test facilities consisted of six independent loops of pavement. Four large loops each 3.1 miles around were built end to end along the eight miles of right-of-way and two smaller loops were built parallel and adjacent to one of the large loops.

Each test loop was built as a straight section of four-lane divided highway with super-elevated turn-arounds connecting the lanes at each end, thus making a closed loop with two continuous lanes. On one side of the pavement was Portland Cement Concrete and on the other side Asphaltic Concrete. This geometry was selected in order to permit incorporating the test road into a planned portion of the Interstate after the test was completed. Figure 1 shows the loop arrangement. For both types of pavement the tangent sections were constructed in short

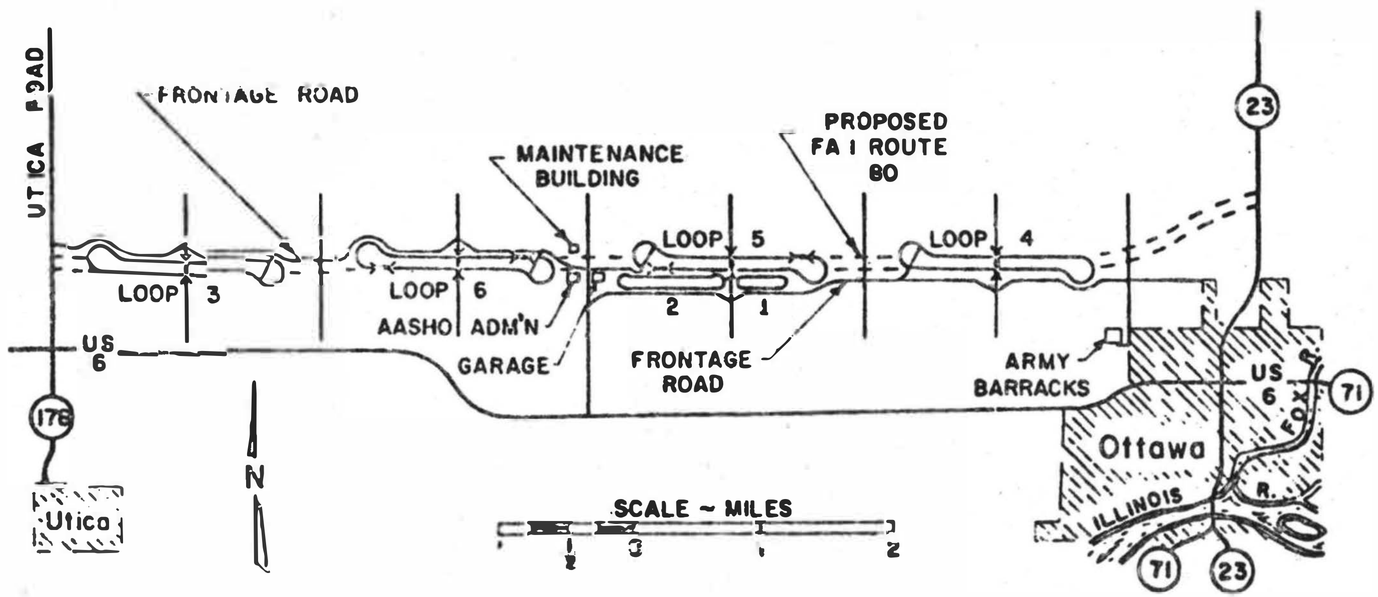


Figure 1. Loop Arrangement

lengths of varied design. There were in total 836 test sections, 368 sections of rigid pavement, and 468 sections of flexible pavement. Thickness of the portland cement concrete slabs varied from 2 1/2 inches to 12 1/2 inches in about 1 1/2 inch steps. Some were placed directly on the subgrade soil, others were placed on the sand-gravel subbase, and the pavements themselves were either plain or reinforced. Thicknesses of asphaltic concrete were from 1 to 6 inches in 1 inch steps, placed either directly on the subgrade soil or on three, six, or nine inch crushed stone base and four, eight, twelve, or sixteen inches of sand-gravel subbase. All possible combinations of these thicknesses were included in the experiment. In selecting the design for the various sections first a nominal design for each loading condition was arrived at by averaging designs submitted by four selected state highway departments and one designed by the project staff. The specific section designs were then varied both below and above this nominal design so that in each experiment some of the test sections were thicker and some thinner than the nominal design. It was estimated at the time that approximately 2/3 of the sections were thinner and 1/3 thicker.

The design factors for the flexible pavements consisted of surfacing thickness, base thickness, and subbase thickness, and each design factor occurred at several levels of thickness in each loop. The experiment is referred to as a "complete factorial experiment," meaning that each level of thickness occurs in combination with each of the other design factor levels of thickness. This provides an extremely strong experiment within a loop. Some of the same thickness levels existed in other loops as well, making a cross-loop experiment, and in each loop a number of test sections were replicated. The test sections within each loop were randomized, thus each test section did not have a choice as to where it would be laid down, providing an even stronger experiment and assuring unbiased results.

Roadway Materials in the AASHO Road Test

Because the principal objective of the Road Test was to determine significant relationships between pavement behavior and the variables of design and loading, it was necessary to control extraneous variables as closely as possible. Thus the aim during construction was to achieve unusual or exceptional uniformity of the embankment and various layers of the pavement structure. In addition, it was anticipated that the Road Test results would be used by a large number of agencies including each of the state highway departments. Therefore, to make the final results more meaningful to the various agencies, samples of the embankment, subbase, and base materials were sent to 60 different interested agencies throughout the United States and Canada. Each of these agencies tested the materials according to standard tests and in some cases standard tests modified by their own particular practices. The results of this entire complex of testing has been summarized by Shook and Fang (3). The variability of the results obtained, even in those tests which were run presumably identically, provided a good indication of how individual differences in technique can influence standard tests. For example, most of the reporting agencies classified the minus 40 fraction of the subbase and base as non-plastic. However, 17 percent gave PI values from 0.2 to 3.4 for the subbase and 29 percent from 0 to 4.3 for the base. In both cases one agency reported a negative PI. Materials test characteristics as determined by the Road Test Staff are presented in Table 1.

Since in the Oklahoma tests the R-value using the HVEEM stabilometer was used extensively, this determination for the AASHO material may be of particular interest. As in some of the other tests, there was considerable difference in

Table 1

Summary of Properties of Base and
Subbase Materials Used at the AASHO Road Construction

Item	Subbase	Crushed Stone Base	Gravel Base	Cement Treated Base	Asphalt Treated Base	Asphaltic Concrete	
						Surface Mix	Binder Mix
Aggregate gradation, % passing:							
1½-in. sieve		100	100				
1-in. sieve	100	90	98	100	100		100
¾-in. sieve	96	80		96	96	100	
½-in. sieve	90	68	74	90	90	92	75
No. 4 sieve	71	50	49	71	71	65	36
No. 40 sieve	25	21	23	25	25	22	13
No. 200 sieve	7	11	9	7	7	5	4
Plasticity index, minus No. 40 material	N.P.	N.P.	3.5				
Max. dry density[2] (pcf)	138	139	140	138	149[3]	151[3]	154[3]
Field density (% max. dry dens.)	102[4]	102	104	101	97	97	97
Asphalt[5] content (% total mix)					5.2	5.4	4.5
Cement[6] content (% by wt.)				4.0			
7-Day compressive strength (psi)				840			
Laboratory tests:							
Marshall stability					1,600	2,000	1,800
Marshall flow					10	11	11
Total voids (%)					6.2	3.6	4.8

[1] Identification: Subbase, uncrushed natural sand-gravel; Crushed stone base, crushed dolomitic limestone; Gravel base, uncrushed natural gravel; Treated bases, asphalt cement or portland cement and subbase material.
[2] AASHO T99-57.
[3] Laboratory density using Marshall procedure.
[4] Before subgrading.
[5] 85-100 penetration grade asphalt.
[6] Type I portland cement.

value determined by various agencies. At a 300 PSI exudation pressure a mean value of 21 may be assumed for the embankment soil, however, the values obtained varied widely from this mean.

The subbase for the AASHO flexible pavement consisted of a sand-gravel material modified by the addition of small amounts of fine sand and friable fine-grained soil. Material was processed in a washing and screening plant and mixed with the fines in a concrete mixer. The subbase was placed in four or eight inch lifts to protect the embankment soils during the winter months.

The base material for the flexible sections was a crushed dolomitic limestone. The material was delivered to the project in two sizes, proportioned by weight, and mixed in a concrete mixer with the amount of water necessary to bring it to optimum moisture content. It was placed on the roadway and rolled in three inch lifts to the required density.

The asphaltic concrete surface course consisted of two sizes of a crushed dolomitic limestone coarse aggregate, a natural silica coarse sand, a natural silica fine-blend sand, and limestone dust mineral filler combined with an 85 to 100 penetration grade paving asphalt. Table 2 shows a summary of the results of 12 tests of the samples from storage tanks at the refinery together with the specification limits for each test. The surface was placed in 1 1/2 to 2 inch lifts using a standard paver. Compaction was by three wheel, pneumatic-tired, and tandem rollers.

AASHO Roadway Construction

In order to simulate as accurately as possible normal highway construction, conventional construction techniques were used except that extraordinary effort was put forth to insure uniformity of all pavement components. For instance, the center 24 foot width of the roadway was kept free of construction equipment,

Table 2

Properties of Asphalt Cement used for Asphalt Mixtures at the AASHO Road Test

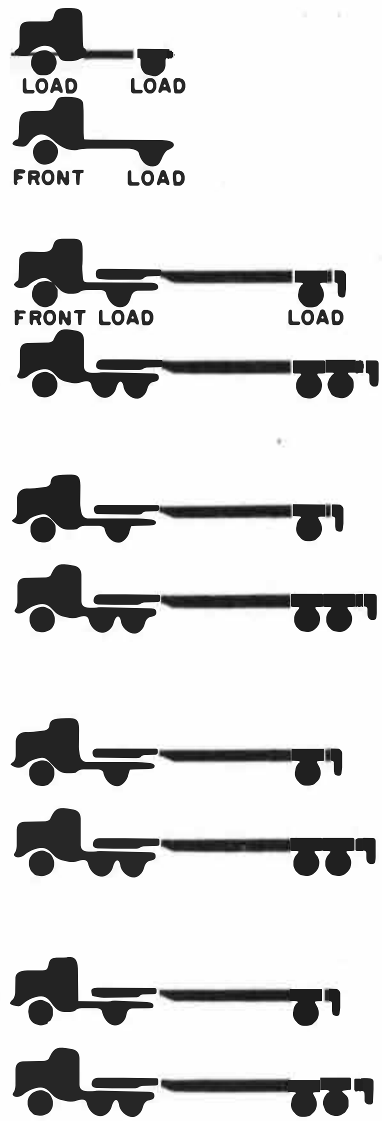
Characteristic	Specification Requirements AASHO Designation: M20–54	Mean Value
Penetration at 77 F, 100 g, 5 sec	85–100	91
Flash point, open cup, (°F)	450+	556
Ductility at 77 F, 5 cm per min (cm)	100+	150+
Loss on heating, 325 F, 5 hr (%)	1.0–	0.03
Penetration of residue from loss on heating test, at 77 F, 100 g, 5 sec, as compared to penetration before heating (%)	75+	84
Solubility in carbon tetrachloride (%)	99+	99.91[1]
Ash (%)	1.0–	0.05
Spot test, standard naphtha solvent	Neg.	Neg.

[1] Solubility in carbon disulfide.

other than that necessary for compaction, and all turning operations on the grade were limited to specially designated transition areas. Construction was performed under contracts negotiated through normal contractual channels. Construction started in late Summer, 1956 and was completed in time for test traffic to begin in the Fall, 1958. Four separate contractors were involved in the total project.

Test Traffic

As previously mentioned, there were six loops in the road test project. Loop 1 was not subjected to test traffic but was used for special studies principally involving the effect of environment on pavements. The remaining 5 loops were subjected to traffic for slightly more than 2 years. Every vehicle in any one of the ten traffic lanes had the same axle load and axle configuration. The assignment of axle loads and vehicle types to the various lanes is shown is Figure 2. The trucks used in the test were loaded with concrete blocks to the design weight. An attempt was made to regulate the speed and transverse placement of the load applications. Tire pressures and vehicle placement were monitored throughout the test. Truck speed was held to a constant 35 miles per hour whenever possible. Traffic was scheduled to operate six days a week, 18 1/2 hours per day, and this schedule was maintained except when truck breakdowns, pavement distress, or bad weather made this impossible. A total accumulation of 1,114,000 axle load applications was attained during the 20 month traffic testing period. This required actual driving of more than 17,000,000 miles.



Loop	Lane	Front Axle	Load Axle	Gross Weight
		Weight in kips		
2	1	2	2	4
2	2	2	6	8
3	1	4	12	28
3	2	6	24	54
4	1	6	18	42
4	2	9	32	73
5	1	6	22.4	51
5	2	9	40	89
6	1	9	30	69
6	2	12	48	108

Figure 2. Arrangement of Axle Loads and Vehicle Types to Various Lanes

AASHO Road Test Measurements

In order to satisfy the several objectives of the road test program, it was necessary to accumulate vast amounts of data during the two years of the road test operation. The cataloguing of these data for ready reference and future availability was a major effort by the road test staff, involving the use of electronic systems to facilitate the storage and initial processing of the data. For the purposes of this report, however, we are mainly concerned with the first objective of the road test which was to attempt to establish relationships between the performance of the pavement and the pavement design variable for various loads. The critical word in this objective statement is "performance".

Pavement Performance

In order to define performance, a new concept was evolved during the course of the road tests, founded on the principle that the prime function of the pavement is to serve the travelling public. It was maintained that a pavement which retained a high level of ability to serve traffic over a period of time was superior in performance to one whose riding qualities and general conditions deteriorated at a more rapid rate under the same traffic. The term "present serviceability" was adopted to represent the momentary ability of a pavement to serve traffic, and the performance of the pavement was represented by its serviceability history in conjunction with its load application history.

It was agreed that the serviceability of the pavement is a matter that must be determined subjectively. It was also agreed that in terms of the road test objective such items as grade, alignment, condition of shoulders, and glare were to be excluded from consideration in arriving at a value for pavement serviceability. In order to quantify the subjective judgment of pavement serviceability, a pavement serviceability rating panel was appointed. This panel included highway designers, maintenance men, administrators, automobile manufacturing interests, and others. These men made independent ratings of the ability of 138 sections of pavement, located in three states, to serve high speed, mixed truck and passenger traffic. Members were instructed to use whatever system they wished in rating each pavement and to indicate their opinions of the ability of the pavement to serve traffic at the time of rating on a scale ranging from 0 to 5 with designations of very poor (0-1), poor (1-2), fair (2-3), good (3-4), and very good (4-5). Road test field crews then measured variations in longitudinal and transverse profiles, as well as the amount of cracking and patching of each of the 138 sections rated by the panel.

Through a multiple regression analysis, the present serviceability ratings by the panel was correlated with the objective measurements of longitudinal profile variations, the amount of cracking and patching and the transverse profile variations or rutting. This analysis resulted in a formula that used pavement measurements to compute a "present serviceability index" which closely approximated the mean rating of the panel. Such measurements were taken at two week intervals throughout the traffic phase of the road test.

The instrument used for recording longitudinal profile variations was the longitudinal profilometer. This instrument, trailed behind a truck operating on the roadway surface, recorded continuously the angle formed by the line of the support wheels and the line connecting the centers of two 8" diameter hard rubber tired wheels arranged in tandem and traveling in the center of the wheel path. The distance between the support wheels being relatively large (25.5 feet) this line was regarded as being approximately parallel to the pavement surface. Since the distance between the centers of the small wheels was only 9 inches the line between these wheels was assumed to be approximately parallel to the tangent to the road surface at a particular point. Thus by measuring continuously the variable angle as mentioned above a close approximation to the longitudinal profile was obtained. The effect of vibration of the tires and springs was held to a low level by restricting the operating speed to five miles per hour and by electrically filtering out high frequencies so that they did not appear on the record. It was realized that the line between the wheels at 25 foot centers was not a completely stable reference and that as a consequence the instrument would not respond correctly to gradual changes in the true pavement slope. Considerable effort was expended to develop an inertial reference means to maintain a true horizontal reference. However, tests indicated that the effectiveness of the instrument with and without such a reference varied so little that the inertial reference was abandoned. Output from this instrument was in the form of a paper tape with a continuous indication of the slope of the pavement. The tapes were fed into an automatic electronic chart reader which measured the ordinants of the chart at intervals corresponding to one foot on the pavement, digitized this information and punched it out on perforated paper tape suitable for use as input to the project digital computer.

During the course of the road tests, improvements were made in the longitudinal profilometer, culminating in the development of a simplified profilometer designated the CHLOE profilometer, whose output is slope variance. Thus neither a chart reader nor a digital computer is required when the CHLOE profilometer is used. The performance of the sections at the road tests was measured by the magnitude of decrease in present serviceability index with the corresponding increase in the number of axle load applications. Numerical calculations required to determine the present serviceability index from the CHLOE readings are detailed in Appendix A.

Road Test Design Equation

The principal single resultant of the Road Test effort, toward which the gathering of the many statistics was aimed, was the production of a design equation embodying the measured factors. The equation may be expressed in different ways, one of which is:

$$\text{Log } W = -0.1952 + 9.36 \log U + \frac{G}{0.4 + \dfrac{1.094}{U^{5.19}}} \qquad (1)$$

where

W = Number of equivalent axle applications (18 kip single)

$G = \text{Log } \dfrac{4.2 - p}{27}$

p = Serviceability index

$U = D + 1$

$D = 0.44\ D_1 + 0.14\ D_2 + 0.11\ D_3$

D_1 = Thickness (in.) of surfacing

D_2 = Thickness (in.) of base

D_3 = Thickness (in.) of subbase

2. SATELLITE ROAD TEST PROGRAM

In order to achieve widespread utility for the research findings from the AASHO road tests, it was necessary to translate them into local conditions. This could be done in two different ways, one by making studies on existing pavement, or two, by constructing special research sections in the various states. (For the Oklahoma satellite study, it was considered most feasible to utilize already constructed highways within the state.) In order to assure the comparability of results of various satellite studies around the country, a guideline was prepared for the use of the several states in conducting satellite studies both for existing pavements and new experimental pavements. (4)

Three types of design variables were considered important for the satellite studies: (1) Structural variables describing the strength characteristics of pavement layers in the roadbed material, the thicknesses of pavement layers, and the overall composite strength of the pavement. (2) Load variables in terms of accumulated axle loads, the number of years over which the accumulation has taken place, and the general rate of axle load accumulation. Load applications are expressed as equivalent 18,000 pound axle loads. (3) Climatic and regional variables describing influences other than load which may lead to performance differences among test sections having the same load and initial structural conditions.

The guidelines give no hard and fast rules as to how each of the variables is to be measured nor does it include analytical procedures for testing existing pavement theories. It was intended to allow sufficient flexibility for each satellite team to introduce its own ideas into the testing program, yet include sufficient test data similar to that being accumulated by other groups to permit direct comparisons to be made.

3. SATELLITE STUDY IN OKLAHOMA

In common with the other satellite studies, it was a general objective of the Oklahoma study to obtain data on existing flexible pavements, including the road-bed structural materials, traffic volumes, and climatic conditions. With these data in hand, along with a measure of pavement performance over a period of time, it was hoped that a correlation could be made with the equations developed from the AASHO Road Test, so that with proper modifications of these equations they could be made applicable to Oklahoma highways within acceptable limits of accuracy. It was planned that the required data be gathered from existing sections of pavement which had suffered appreciable loss in serviceability but had received no major maintenance and from new pavements constructed during the course of the investigation. Sections were to be selected from each of two specified regions in Oklahoma representing distinct climatalogical areas of the state.

In so far as possible, sections within regions were to be chosen to conform to requirements of a balanced, factorial experiment wherein the controlled design variables were

A. rate of accumulations of load applications,

B. surfacing thickness,

C. thickness and/or strength of layers below the surfacing.

The seven specific independent variables included surface thickness, base-type and thickness, subbase thickness, sub-grade quality, load applications, and climatic differences. With sufficient data on these independent variables together with a measure of change in serviceability index over a period of time, it should be theoretically possible to fit these data into the design equations developed during the AASHO Road Test, thereby obtaining a set of coefficients which would have the effect of making the Road Test equations applicable to Oklahoma conditions.

The problem is of course not nearly so simple as just stated. Major difficulties are likely to arise from interaction between some or all of the variables, although the data from the Road Test indicated that as far as the design variables of layer thickness and quality are concerned interaction is slight. A second and in some ways more perplexing problem is inherent in the use of existing roads for test purposes. This is the fact that a complete factorial is not possible, since for example in real road construction one does not build a poor quality highway with thin layers of roadbed structure where traffic is high. The incomplete factorial that is obtained is likely to cause great, if not insurmountable difficulties from a statistical point of view. This will be discussed more fully in a later portion of this report.

The inability to obtain an initial present serviceability index, p_o, and the problems involved in determining a performance trend are additional major difficulties inherent in this type of experiment.

4. EXPERIMENT DESIGN

A factorial experiment was designed for this project. The factors in the experimental design include climate condition, traffic history, surface thickness, base type, base thickness, subbase thickness and subgrade classification. There are three variations or levels in base type and two variations in each of the other factors, thereby forming 192 combinations in a 3×2^6 factorial experiment. Originally a third level of subgrade classification was included; however, during the course of the program it was decided to reduce the subgrade classifications to two levels, since with the roadway sections available for study a more complete factorial design was thus obtained. A detailed description of the factors and the levels at which each factor occurs is shown below.

Factor	Levels
Climate condition	Ave. annual precipitation ≤ 33" Ave. annual precipitation > 33"
Traffic condition	Ave. daily traffic vol. ≤ 3300 Ave. daily traffic vol. > 3300
Surface thickness	< 2 1/2" 2 1/2" - 5"
Base type	Sand Asphalt Black Base Stabilized Aggregate
Base thickness	≤ 8" > 8"
Subbase thickness	< 6" > 6"
Subgrade quality	A-5 and up A-1 - A-4 and A-2-7

The first factor, climate condition, was divided into the two areas of precipitation less than 33" and greater than 33" because there is a considerable gradient in precipitation across the state. The 33" precipitation line falls in a nearly north-south direction across the middle of the state and corresponds to about an average rainfall for the entire state. The second factor, traffic, was divided into two levels with a break at the 3300 vehicles per day level. A study of traffic volumes throughout the state indicated that this level for Oklahoma constituted a point at which it could be said that traffic in excess of this amount was high and below this amount was relatively low, with about the same mileage of state highways occurring in either area. Surface thickness was divided at the 2 1/2" level because surface thicknesses less than this amount are prescribed for lightly traveled roads whereas on more heavily traveled roads surface thicknesses are always in excess of 2 1/2 inches. The three selected base types represent three types of base used on flexible roads in Oklahoma, all in significant amounts. It would be desirable from a statistical standpoint to divide this item into two levels corresponding to the number of levels of the other items in the factorial. However, because there were significant mileages of each of these base types, it did not appear realistic to limit this item to two levels. The two items, base thickness and subbase thickness were divided each into two levels, again based on normal construction practice in Oklahoma. The final factor, subgrade quality, uses as a basis for measurement the AASHO classification system, although normal classification system used in design of Oklahoma pavements involves the Oklahoma Subgrade Index (OSI). For the purposes of this test, however, it was decided to employ the more generally accepted AASHO system in order to make comparison with other states possible. Originally, three levels of this factor were arbitrarily selected. These were: good, A-1, 2, 3, 4 (OSI less than or equal to 10); fair, A5 - A6 (10), also A2 - 7 (OSI 11-20); poor, A6 (11) and up (OSI greater than 20). During the course of the project the number of levels of this factor was reduced to two, as mentioned above, based on the subgrade quality found to be in place. The reduction to two levels also aided the proposed statistical analysis.

5. SAMPLING AND FIELD EXPERIMENTS

Test Site Selection

The purpose of this phase was to select, among the existing flexible pavements, sections of highway whose structural, climatic and traffic variables would compose any one of the combinations described previously.

The initial step in this portion of the project was the preparation of a listing of projects constructed by the Oklahoma Highway Department over the previous ten year period. It included both rigid and flexible pavements. From this listing a first selection of flexible projects was made. Projects less than one mile in length were not considered and certain other projects were eliminated for various reasons. In general, the eliminated projects contained complicating factors such as overlays over previously constructed roadways.

The information given in these first listings did not contain all the necessary factors for the analysis; hence, the next step was to go to the "as built" plans and also the original soil survey data in the highway department files. During this winnowing process it was found, as expected, that a number of spaces in the factorial design were more than adequately filled and that a number of spaces were not filled at all. A diligent search was made for sections which would supply the information needed for these empty boxes in the factorial. However, it was found that many combinations of the factors did not exist.

As a final step in the process of site selection, personnel from both Highway Department and University were organized to make the field selection of test sites. In each of the selected highway construction projects a section of 1000 ft. length, with adequate sight-distance in both directions, was marked and properly identified with a Test Site Number. Five hundred foot sections were chosen whenever it was not feasible to select longer ones due to limited sight-distance. Sight distance limitation was also responsible for the elimination of some potential sites. In addition, certain sections were eliminated where identical designs would have led to excessive replication. Location of sites selected is shown in Fig. 3 and tabulated in Table 3.

During the field selection of test sites, several other cautions were followed, in addition to making sure that sufficient sight-distance existed for adequate safety of the CHLOE crew. Among these was the requirement that an entire 500 ft section be either on fill or in cut. This was done because it was felt that there might be random roughnesses introduced in going from cut to fill or fill to cut sections, thus introducing an additional unwanted variable. The field selection crew also followed the policy of selecting sections in which the grade was continuously positive or negative through the test section, since prior experience with the CHLOE had shown that a change from positive to negative grade had an adverse effect on the accuracy of the readings. In thus restricting the test sites, a score or more of potential test sites were eliminated.

Determination of Present Serviceability Index

Following the completion of test site selection, surface roughness of each section was obtained by Highway Department personnel. In this operation, slope variance was determined by using the CHLOE profilometer

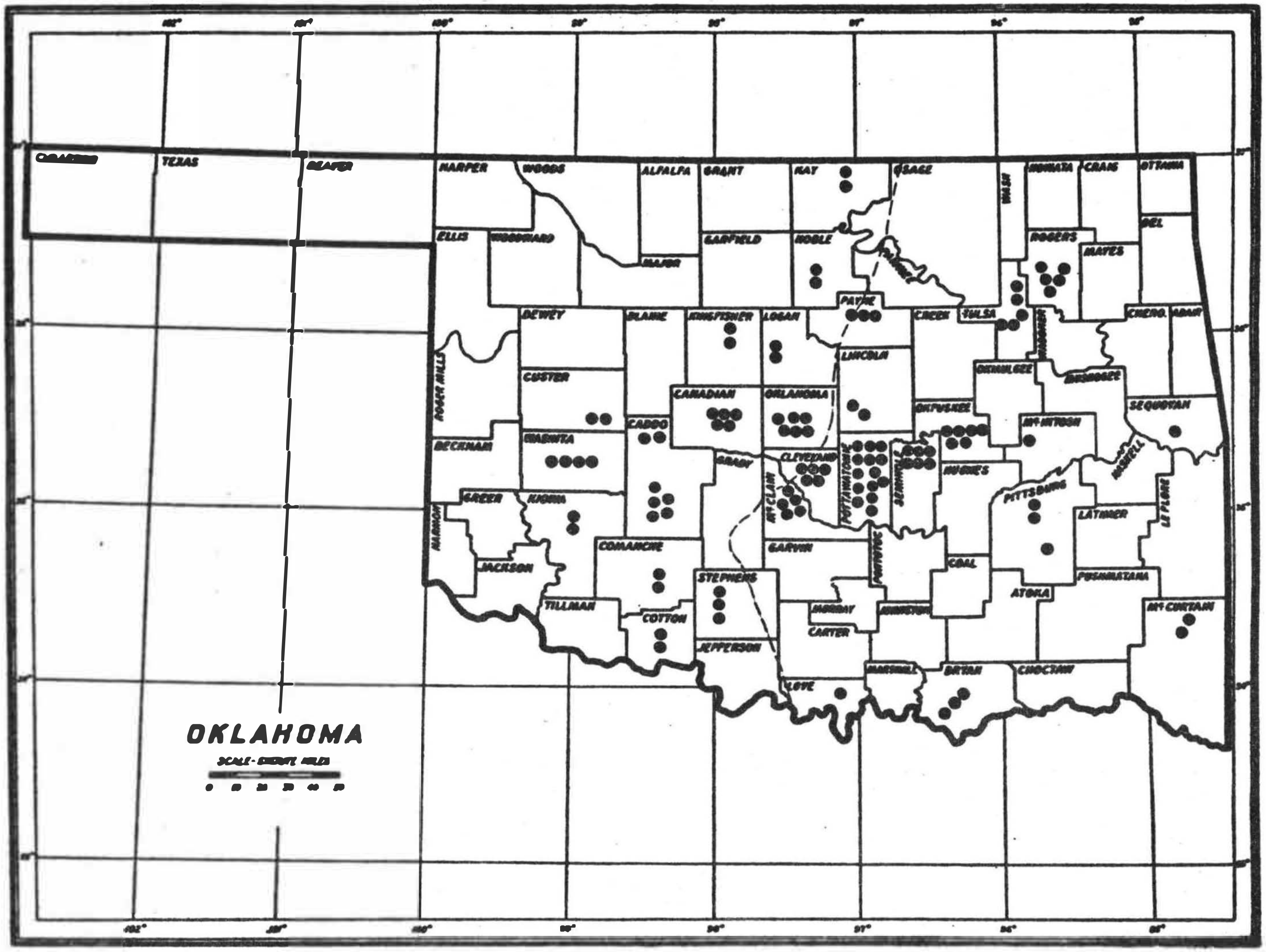


Figure 3. Location of Test Sites

TABLE 3

LOCATION OF TEST SITES

Test Site Number	Length Feet	Date of Completion	County	Approximate Location
3	500		Oklahoma	.20 miles E. of Sunnylane Road on I-40
4	500	11-62	Pott.	E. of T.S. No. 3, Beg. at Sta. 1140+00, on I-40
7	500	11-62	Pott.	E. of T.S. No. 4, Beg. at Sta. 1275+00, on I-40
9	500	11-62	Pott.	E. of T.S. No. 7, Beg. at Sta. 1356+00, on I-40
11	500	11-63	Pott.	E. of T.S. No. 9, Beg. at Sta. 1511+00 on I-40
13	500	11-63	Pott.	E. of T.S. No. 11, Beg. at Sta. 1543+00, on I-40
17	500	11-63	Pott.	E. of T.S. No. 13, Beg. at Sta. 1622+00, on I-40
26	500	5-63	Pott.	N. of Shawnee, on US-270
33	500		Roger	N.W. of Claremore, on SH-88
34	500		Roger	N. of T.S. 33, on SH-88
37	500		Roger	N. of T.S. 34, on SH-88
38	500	2-58	Roger	N. of Catoosa exit, on US-66
40	500	2-58	Roger	N. of T.S. 38, on US-66
42	1000	6-62	Tulsa	Near Owasso, on US-75
43	1000	6-62	Tulsa	S. of Owasso exit, on US-75
44	500	12-57	Kingf.	2.5 miles s. of Hennessey, on US-81
45	500	12-57	Kingf.	N. of T.S. 44, on US-81
47	1000		Kay	1.3 miles S. of Kansas, on US-77
48	1000		Kay	Near Chilocco, on US-77
50	1000	3-63	Noble	4 miles N. of US-64 & I-35 Jct. on I-35
51	500	3-63	Noble	S. of T.S. 50, on I-35
57	1000		Tulsa	Broken Arrow Expressway
58	500		Tulsa	N. of T.S. 57, at Sta 105+00
68	500		Tulsa	N. of T.S. 58, at Sta 548+00
72	1000	5-63	Pott.	Near Shawnee, on US-270
74	500	5-63	Pott.	Near Shawnee, on US-270
76	1000		Pott.	Beg. at Sta. 180+00, on US-177
77	1000		Pott.	Beg. at Sta. 276+00, on US-177
80	500	5-64	Lincoln	Near Meeker, on US-62
82	500		Lincoln	Beg. at Sta. 798+00, on US-177
88	500	11-62	Pott.	N. of Shawnee, on I-40

Test Site Number	Length Feet	Date of Completion	County	Approximate Location
91	500	11-62	Pott.	N. of Shawnee on I-40
92	500		Seminole	Beg. at Sta. 9 + 00, on I-40
98	500		Seminole	E. of T.S. 92, on I-40
100	500		Seminole	E. of T.S. 98, on I-40
103	500		Seminole	E. of T.S. 100, on I-40
106	1000		Seminole	E. of T.S. 103, on I-40
107	500		Seminole	E. of T.S. 107, on I-40
108	1000		Okfuskee	E. of Jct. SH-27 & I-40, on I-40
111	1000		Okfuskee	E. of T.S. 108
114	500		McIntosh	Beg. at Sta. 52+00, on I-40
123	500		Sequoyah	Beg. at Sta. 245+00, on I-40
130	1000	11-59	McCurtain	S. of Smithville, on US-259
131	1000	6-61	McCurtain	S. of Smithville, on US-259
135	1000	6-62	Bryan	N. of Red River, on US-69
136	1000	6-62	Bryan	N. of T.S. 135, on US-69
137	1000	6-62	Bryan	N. of T.S. 136, on US-69
145	500	2-61	Cleve.	S. of Clev.-Okla. Co. Line on I-35
151	1000	10-63	Cleve.	Beg. at Sta. 423+00, on I-35
152	1000	10-63	Cleve.	Beg. at Sta. 628+00, on I-35
153	500	10-63	Cleve.	Beg. at Sta. 646+00, on SH-9
155	1000	10-63	Cleve.	Beg. at Sta. 744+00, on SH-9
157	500	5-60	Payne	E. of Stillwater, on SH-51
158	500	5-60	Payne	E. of Stillwater, on SH-51
159	500	5-60	Payne	E. of Stillwater, on SH-51
160	1000	9-62	Canadian	Beg. at Sta. 890+00, on I-40
161	500	9-62	Canadian	W. of T.S. 160, on I-40
164	500	9-62	Canadian	W. of T.S. 161, on I-40
165	1000	9-62	Canadian	W. of T.S. 165, on I-40
167	1000	9-62	Canadian	S. of Calumet, on US-270
169	1000		Caddo	Beg. at Sta. 5400+00, on I-40
170	1000	5-59	Custer	Beg. at Sta. 3440+00, on I-40
176	1000	5-59	Custer	Beg. at Sta. 3157+00, on I-40
177	1000	1-64	Washita	S. of Foss, on SH-44
179	1000	9-64	Washita	Near Dill City, on SH-42
180	1000		Washita	S. of Jct. 152&44, on SH-44
181	1000		Washita	S. of T.S. 180, on SH-44
184	1000		Kiowa	Beg. at Sta. 1430+00, on SH-19
185	1000		Kiowa	Beg. at Sta. 1470+00, on SH-19
188	1000	7-64	Caddo	Beg. at Sta. 637+00, on SH-58
191	1000	7-64	Caddo	Beg. at Sta. 400+00, on SH-58
192	500	7-64	Comanche	Beg. at Sta. 383+00, on SH-58
193	1000	7-64	Comanche	Beg. at Sta. 258+00, on SH-58
196	1000		Cotton	N. of Red River, on US-281
198	1000	7-56	Cotton	Beg. at Sta. 1299+00, on US-281
199	500	7-56	Stephens	N. of Duncan, on US-81
201	1000	7-56	Stephens	N. of T.S. 199, on US-81
205	1000		Stephens	W. of US-81, on SH-7

Test Site Number	Length Feet	Date of Completion	County	Approximate Location
206	1000	7-58	Caddo	S. of Anadarko, on SH-8
207	1000	7-58	Caddo	S. of Anadarko, on SH-8
208	1000	7-58	Caddo	Beg. at Sta. 699+00, on SH-8
210	1000	9-63	Okla.	In Okla. City, on SW 74th St.
211	500	9-63	Okla.	In Okla. City, on SW 74th St.
213	500	9-63	Okla.	In Okla. City, on SW 74th St.
215	1000		Pott.	Beg. at Sta. 166+00, on US-177
217	1000		Okfuskee	E. of Sem-Okf. Co. Line, on I-40
218	500		Okfuskee	E. of T.S. 217, on I-40
219	1000		Okfuskee	E. of T.S. 218, on I-40
220	1000		Okfuskee	E. of T.S. 219, on I-40
222	1000	9-62	Pitts	S. of Indianola, on SH-113
224	1000	9-62	Pitts	S. of Indianola, on SH-113
230	500	10-56	Love	N. of Marietta, on US-177
236	1000		Okla.	In Okla. City, on Reno St.
239	1000		Logan	S. of Crescent, on SH-74
240	1000		Logan	S. of Crescent, on SH-74
246	1000	7-64	McClain	N. of Turnpike, on Serv. Rd.
247	500	7-64	McClain	On SH-37
248	1000	7-64	McClain	Near Okla. City Line on Exp.
249	1000	7-64	McClain	N. of Turnpike
250	1000	7-64	McClain	N. of Turnpike
251	1000	9-63	Okla.	Near May Ave. Overpass; Serv. Rd. on 74th
253	1000		Caddo	W. of Bethel Rd., on I-40
254	1000	10-57	Pitts	S. of McAlister, on US-69 Serv. Rd.

shown in Figure 4, rutting was measured by the device shown in Figure 5, and extent of cracking and patching was obtained by visual observation. The measurements were made on each wheel path of the test sites in the direction of traffic. On divided highways, it was decided to evaluate one roadway picked out randomly.

The first set of roughness data was collected within a six-month period. After an eighteen month interval, a second evaluation of pavement roughness on all sections was accomplished. Appendix B shows a typical data sheet for this field work. Both sets of data were processed by Oklahoma State University personnel to determine the values of Present Serviceability Index (PSI). Appendix A illustrates the procedure of computation for PSI determination.

Sampling and Field Testing of Paving Materials

Highway Department field crews were responsible for the major part of the work in this phase. A summary of the type of field tests used is shown in Table 4. Sampling and testing were performed on the outer wheel-path as it was believed that pavement deteriorated more rapidly in this portion of the roadway. A rotary drilling rig attached to a pick-up truck, as shown in Figures 6 and 7, was used to core the asphaltic concrete surface, sand asphalt and black base. These cores had four-inch diameters as specified in the Marshall Method for stability testing.

In order to provide operating space for determination of moisture content, thickness, and density of the structural layers below the roadway surfacing, a six-inch core hole was drilled to the necessary depth. For the density determination, the stabilized aggregate base dictated the use of the rubber balloon method only whereas the subbase and subgrade permitted the use of the Shelby tube method as an alternate method.

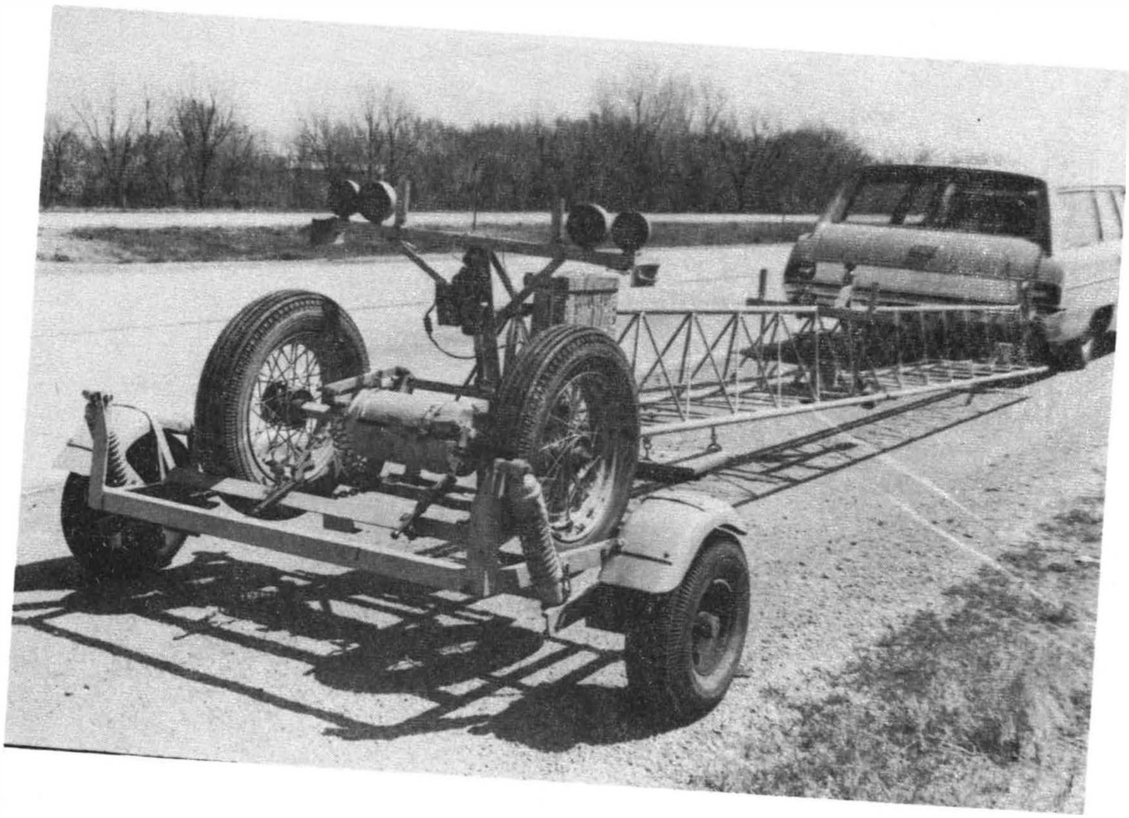


Fig. 4. CHLOE Profilometer

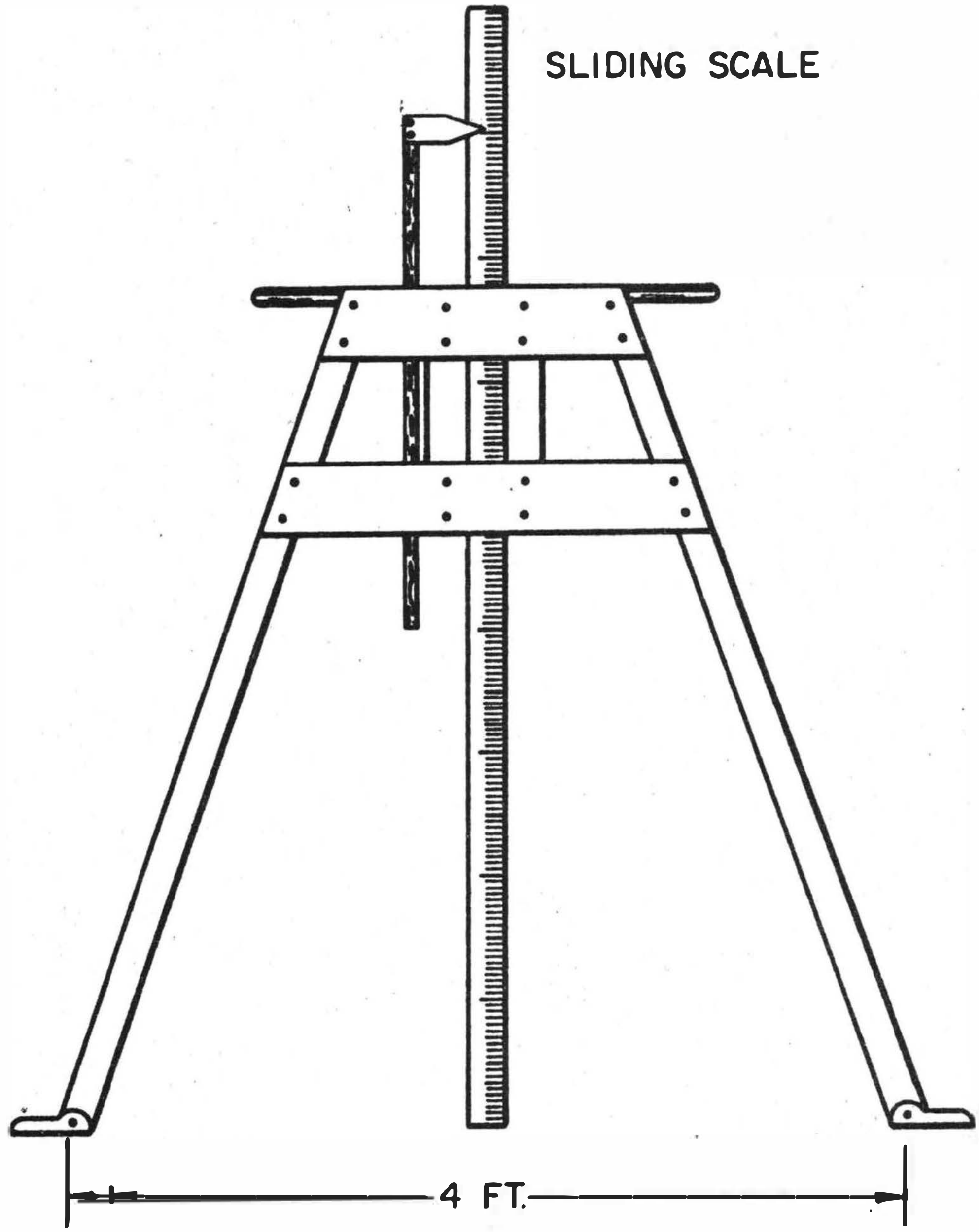


Figure 5. Device for Measuring Rut Depth

TABLE 4

MATERIAL TESTING FOR AASHO RESEARCH

	Surface	Base	Subbase	Subgrade
Field Moisture Content Determination		*	X	X
Density and Thickness Determination				
Rubber Balloon Method		*	X	X
Shelby Tube Method			X	X
Marshall Method	X	X		
Plasticity Index Determination			X	X
Sieve Analysis		*	X	X
Standard Proctor Test			X	X
Stability Determination				
Marshall Method	X	X		
Hveem Method		*	X	X

Note: * for Stabilized Aggregate Base

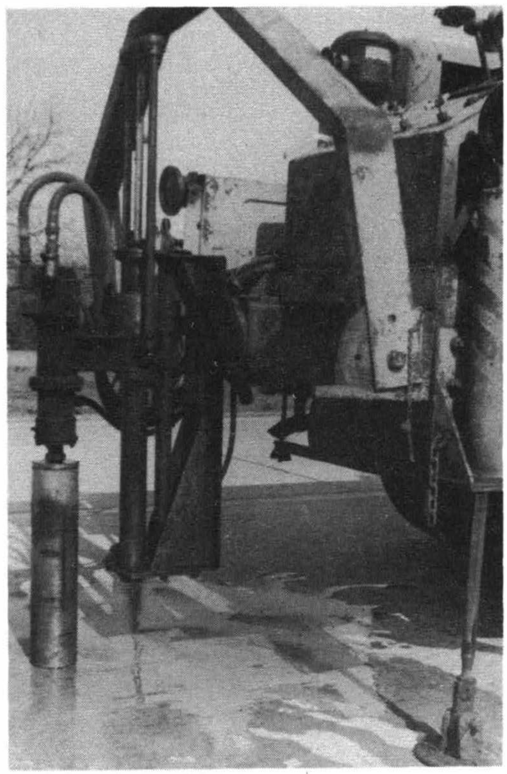


Fig 6. Drilling Rig Attached at the Rear of a Pick-up Truck

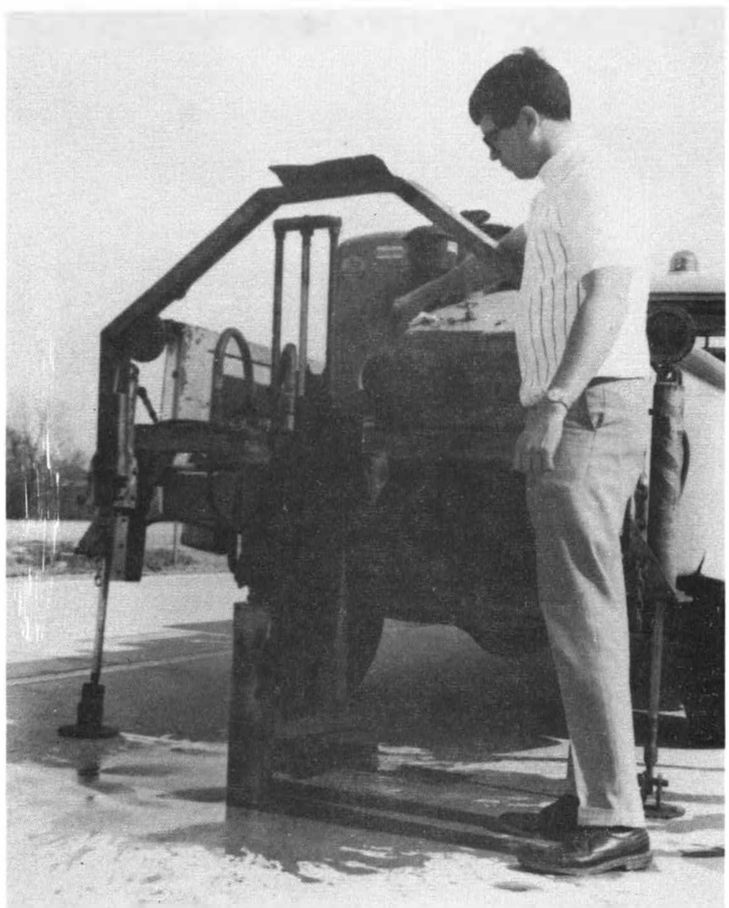


Fig. 7. Coring of Flexible Pavement

Following field testing of the roadway materials, additional material samples were obtained for laboratory tests. Additional six-inch holes were drilled to provide approximately 30 lbs of material from each layer of the pavement section. For each test site of the project, a typical set of sampled materials included surface core, base core, density sample from balloon method, Shelby tube sample and a bulk disturbed sample. The materials were then transported to OSU for laboratory investigations.

6. EVALUATION OF PAVEMENT PERFORMANCE

Introduction

In highway engineering practice, the objective is to design and construct roadways which will promote safe, comfortable, and expeditious travel, and at the same time will be durable and economical to build and maintain. These desirable roadway characteristics, with the exception of economy, may be referred to inclusively as pavement performance. Although evaluations of pavement performance depend upon individual opinions, and as a consequence, vary widely between one person and another, a necessary part of the AASHO research project was to develop an objective means of defining pavement performance.

Pavement performance is the time history of pavement traffic-carrying ability, or serviceability. Pavement serviceability is perhaps the most controversial of any of the variables connected with the road test. There is difficulty in reaching agreement on the index of serviceability at any one time and there is also a question of whether the serviceability index as determined has a direct relationship to the future effectiveness of the highway as a medium for travel. Road test staff members Carey and Irick (5) define serviceability as the subjective opinion of highway users as to how they are being served by the highway. Since this is a subjective definition, there will obviously be differences of opinion among the raters. Thus a numerical value for serviceability would have to be taken as a mean of a number of highway raters. This was exactly the method adopted in the AASHO road test. As mentioned in the introduction chapter, a panel was selected which subjectively rated the present serviceability of a number of pavements on a numerical scale ranging from 0 to 5. Although individual ratings were significantly different, a comparison of ratings by different panels showed an insignificant difference. The conclusion seemed to be that rating by a panel of five to ten persons is quite reliable and reproducible method for obtaining a serviceability rating. In the process of investigating panel rating as a method, using the 0 to 5 scale established by the AASHO staff, it was learned that a figure of 2.5 is acceptable, on the average, for primary highways. Below that figure some maintenance is required and below a figure of 1.5 complete rebuilding of the highway is required.

It appears quite evident that the principal contributor to a subjective rating of pavement performance is surface roughness. Many devices have been developed by engineers for measuring pavement roughness. The Bureau of Public Roads (BPR) Roughometer, California Profilograph, and Midwest Research Institute Profilometer have made their contributions to highway roughness evaluation. Certain disadvantages in these devices have limited their application to roadway evaluation. However, a Road Test Profilometer was developed and used throughout the AASHO Road Test. Toward the end of the Road Test, the CHLOE Profilometer, a simpler device with characteristics similar to the Road Test Profilometer, was developed. Its slope-measuring wheels at the rear of a trailer, as shown in Figure 8, measure the pavement slopes along the vehicle wheel path. The horizontal reference for the slope angle is the 30 ft trailer tongue. During the operation of the CHLOE Profilometer, the trailer is towed behind a vehicle at 5 mph. An electronic device attached at the end of the trailer registers the angles of pavement slope detected by the slope wheels at discrete intervals of six inches, and feeds them into the CHLOE computer (Fig. 9) which is placed inside the towing vehicle. The

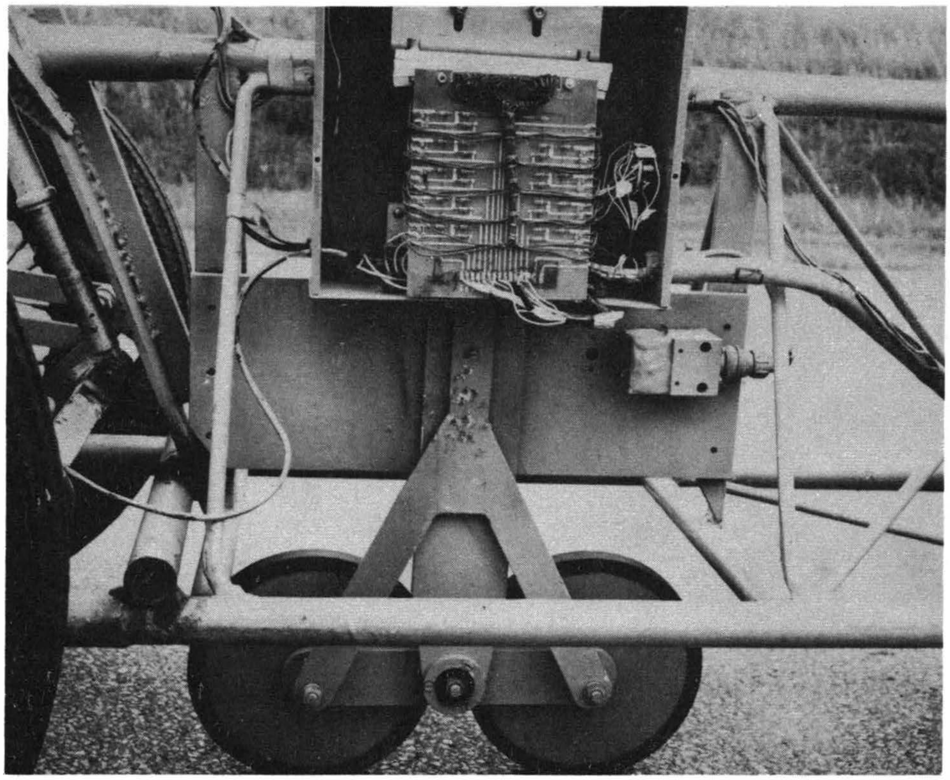


Fig. 8. Slope Wheels of the CHLOE Profilometer

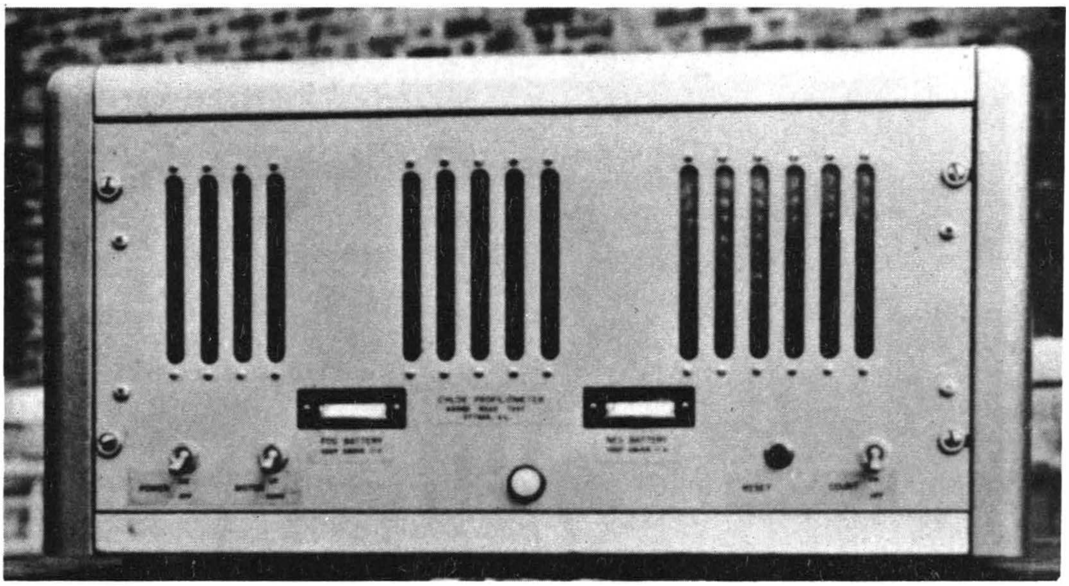


Fig. 9. Computer of the CHLOE Profilometer

computer simultaneously calculates the sum and the sum of the squares of these slope values. When the machine stops, the computer console indicates the accumulated number of measurement samples taken by the CHLOE Profilometer. From these three statistics, slope variance is found by using the equation:

$$CSV = \frac{\Sigma Y^2}{N} - \left(\frac{\Sigma Y}{N}\right)^2$$

where CSV = slope variance obtained with the CHLOE

Y = value of slope angle

N = number of Y's sampled

Since the numbers recorded by the CHLOE represent successive 10 minute arcs, the variance as corrected to radian measure is then

$$CSV = 8.46 \left\{\frac{\Sigma Y^2}{N} - \left(\frac{\Sigma Y}{N}\right)^2\right\}$$

where CSV is the actual slope variance multiplied by 10^6.

<u>Serviceability Rating</u>

In order to relate the output of existing roughness measuring devices to pavement performance, a correlation study was conducted by AASHO Road Test staff. The Pavement Serviceability Rating Panel, previously referred to, was organized to perform the subjective pavement rating on a scale from 0 to 5. The relation between the subjective rating and scaling is shown below.

Very Good	4 - 5
Good	3 - 4
Fair	2 - 3
Poor	1 - 2
Very Poor	0 - 1

After the rating of a number of roadway sections throughout several northern states was completed by the Rating Panel, various objective measurements were made on the same sections, including cracking and patching, transverse profiles, and longitudinal roughness by BPR Roughometer and Road Test Profilometer. As a result of a statistical analysis, the correlation between the subjective rating and the slope variance from Road Test Profilometer appeared to be best. Therefore, slope variance was chosen as a means for pavement roughness evaluation in the AASHO test. Analysis of the correlation between the slope variances obtained with CHLOE and the Road Test Profilometer used at AASHO, provided a correction term when the CHLOE slope variance was used to estimate pavement performance (6). The corrected equation for CHLOE slope variance is

$$SV = 8.46\ [\frac{\Sigma Y^2}{N} - (\frac{\Sigma Y}{N})^2] - 3.0$$

or SV = CSV - 3.0.

Present Serviceability Index

If it were practical for a rating panel to rate desired sections of road often enough, no measurements would need to be taken. In that case, analyses of the relationship between design variables and pavement conditions could be based on a pavement serviceability rating (PSR) as determined by the panel. Since this is not practical, it was necessary in the Road Test to establish an objectively obtainable PSI or pavement serviceability index that would predict the panel's ratings. To accomplish this measurement certain physical characteristics of the pavements were necessary to aid in determining which measurements might be useful. Members of the panel were asked to indicate which measurable features of the roadway influenced their ratings. The primary features mentioned were longitudinal and transverse profile with some significant likelihood that cracking and patching would contribute. All of these characteristics were measured on the road sections rated by the AASHO panel. The decisions as to which terms should be in the serviceability formula and which terms may be neglected were made by comparing predictions made by various combinations of the measured values with the ratings of the panel. This is more easily said than done since it involves a considerable amount of multiple linear regression analysis to yield a combination of ingredients that will produce estimates corresponding to the ratings of the panel with sufficient accuracy. A general mathematical equation for present serviceability index was therefore formulated as follows:

$$PSI = C + (A_1R_1 + A_2R_2 + \ldots) + (B_1D_1 + B_2D_2 + \ldots)$$

where R_1, R_2, ... are functions of profile roughness and where D_1, D_2, ... are functions of surface deterioration such as rut depth, cracking and patching. The coefficients C, A_1, A_2, B_1, B_2, ... were then determined by a lengthy least squares regression analysis.

Taking rut depth, cracking, and patching into consideration, a formula for computing the Present Serviceability Index (PSI) for flexible pavement was eventually established as below.

$$PSI = 5.03 - 1.91 \log (1 + \overline{SV}) - 1.38\ \overline{RD}^2 + 0.01\sqrt{\overline{C}} + \overline{P}$$

where $\overline{SV}$ = mean slope variance

$\overline{RD}$ = mean rut depth, in 10^{-1} inch

$\overline{C}$ = cracking per 1000 sq. ft.

$\overline{P}$ = patching per 1000 sq. ft.

Each of the values $\overline{SV}$ and $\overline{RD}$ is the average of its measurements made on both vehicle wheel paths.

A computer program was written for IBM 1620 to calculate the Oklahoma PSI values. Appendix A contains this program. Results of PSI determination and the data obtained through pavement roughness measurement are given in Appendix C.

Pavement Performance

Having determined the present serviceability index, which presumably is the estimate of themomentary ability of the pavement to carry high speed traffic, it next becomes desirable to relate changes in this serviceability index to pavement performance. If serviceability index values of a test section are plotted against accumulated loads at successive points in time the resulting graphs represent performance records for the section. These differences in serviceability index are the total result of all elements acting on the pavement including traffic, weather, time, the structural design variables of the roadway, and the nature of the subgrade or basement soil.

Experience with the present serviceability index has shown that most new pavements have PSI values in the range from 4 to 5 and a nationwide survey of terminal serviceabilities indicated that an average terminal serviceability level is about half the initial level or between 2.0 and 2.5. By terminal serviceability here is meant the level at which the road is in need of major reconstruction. The guidelines for satellite studies of pavement performance suggest that a drop of at least 1.0 in serviceability from the initial value is about the minimum difference from which an adequate indication of performance can be obtained. Obviously the greater range in index value and the larger the number of observations made of the serviceability index, the better will be the estimate of performance.

In this satellite study, the original intent was to base the performance trend on an assumed initial serviceability index and one set of observations. Results from other states indicated that this would introduce considerable inaccuracy, therefore, two sets of estimated PSI values were made within two years, on the selected test pavements. Results of primary analysis on the differences between those two sets of PSI values are summarized in Appendix D.

7. LABORATORY TESTING OF PAVEMENT MATERIALS

Introduction

Field tests and sampling procedures were discussed in Chapter 5 of this report. Highway Department personnel procured materials samples in conjunction with the field testing. The properly labeled samples were transported from the Highway Department to the OSU Laboratory in the quantities required for classification and strength tests. In the laboratory, disturbed samples were air dried and stored in four-gallon metal containers. To ensure systematic material processing, these containers were so arranged on shelves that material of any particular test site could be easily located. Undisturbed cores and density samples were stored in laboratory closets specially prepared for this research project. The required tests of pavement materials are indicated in Table 4. For most of the laboratory tests, readers can find the detailed procedure from references stated in the following sections. However, necessary modifications of standard procedures will also be discussed in the text.

Moisture Content Determination from Density Samples

During the field density determination, the wet weight of each sample tested by rubber balloon method was obtained before placing the material in canvas bags. Dry weight of these samples was determined in the laboratory, following a 24-hour oven-dry (110°C) period. The dried materials were then retained in the bags which were identified with labels.

Shelby tube samples did not require any field measurements during sampling since these samples were protected against loss of moisture. Wet material in

Shelby tubes was extruded from the tube in the laboratory to prevent it from adhering to the tube when it was dried. After obtaining the moist weight, material separated from the tube was oven-dried before the dry weight was measured.

Properties Determination for Surfacing, Sand Asphalt Base and Black Base Cores

It was decided to measure the density, thickness, and Marshall stability and flow of each flexible material core which was sampled according to the procedure described in the previous chapter.

Thicknesses of surface and base obtained by measuring the cores are presented in Appendix E.

Samples of 2 1/2" thickness are recommended in the Marshall test (MS-2, The Asphalt Institute) for stability and flow determinations. A concrete saw shown in Figure 10 was used to cut the cores into the necessary thickness. A diamond blade was used and proved to be very suitable for this purpose. A good supply of cooling water was necessary during the cutting operation.

Density of the cut core could be determined as soon as the core was air-dried. Weighing the core in both air and water, density was obtained from the ratio between weight of core in air and volume of water displaced by the core.

Special care was exercised in testing the sand asphalt and black base cores. If the porosity and surface texture did not allow the use of the above method, specimens were coated with paraffin whose specific gravity was known, before weighing. In this case, Method A in Appendix B (MS-2, The Asphalt Institute) was used. Results of this test are summarized in Appendix E.

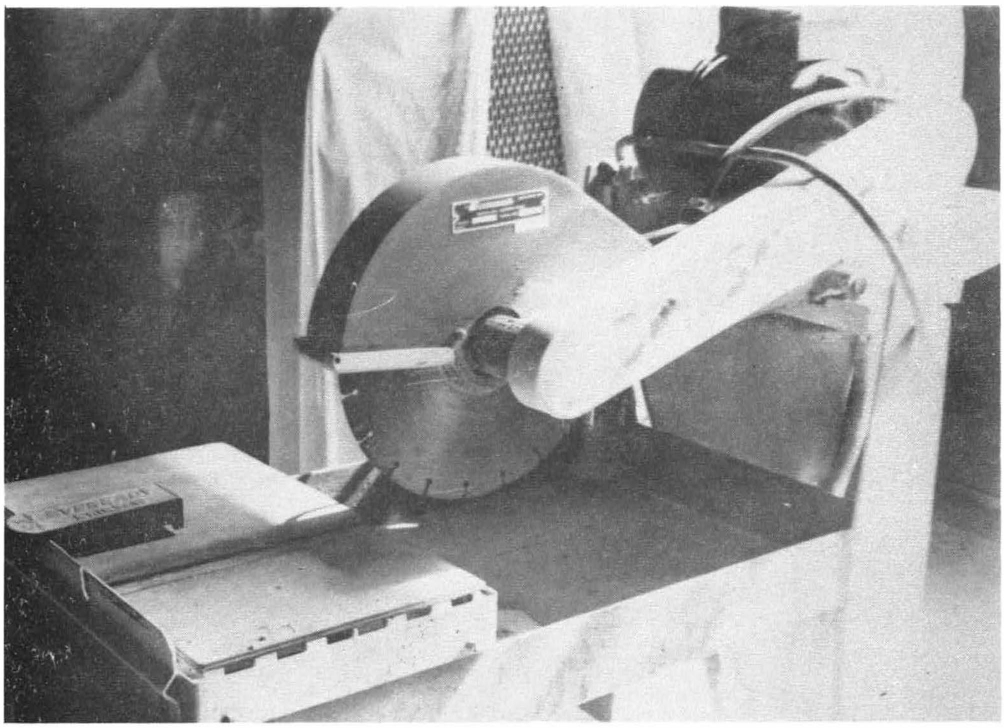


Fig. 10. Concrete Saw

Stability and flow tests followed the procedures described in the same reference (MS-2, The Asphalt Institute). An electrically powered testing machine with the flow meter attached at the top of the semi-circular testing head is shown in Figure 11. Restricting the time interval of the immersion of specimens in water bath was important when there was a large batch of cores to be tested. Summary of the results in this test are given in Appendix E.

Sieve Analysis

With AASHO T-27-60 and T-11-60 in the AASHO Highway Materials, Vol. II, 1966, as references, Oklahoma Highway Department has its own testing procedure developed for sieve analysis. For details of this method, readers are referred to the Oklahoma Laboratory Testing Procedure, 1967. The method included analyses for stabilized aggregate, subbase and subgrade materials. Sieves were so chosen for various materials that the sizes were as compatible as possible with those specified in the AASHO report. Summary of the analyses is included in Appendix F.

Plasticity Index Determination

Plasticity Index was determined on subbase and subgrade materials of the test pavements. Samples were prepared and tested according to the procedures described in Part II of the ASTM procedures for Testing Soils, 1964 (D 421-58, D 424-58, and D 423-61T). Appendix F summarizes the results of these tests.

Moisture-Density Relations of Subbase and Subgrade Soils

The Standard Proctor Test, using a 5.5 lb rammer and 12 in. drop, was selected for determining the moisture-density relations of subbase and subgrade materials. ASTM Procedures, D 698-64T, Method A, were followed. The

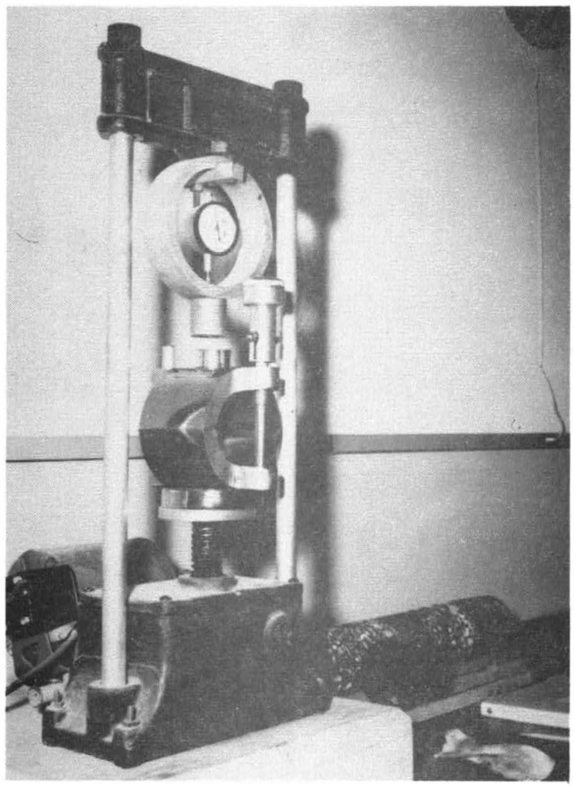


Fig. 11. Device for Marshall Stability and Flow Test

automatic mechanical compactor produced more satisfactory compaction than manual compaction, with relatively faster operation during this routine process. Results are tabulated in Appendix F.

Deformation Resistance of Stabilized Aggregate Base, Subbase, and Subgrade Materials

Stabilities of these materials were determined by the Hveem stabilometer test. California pavement design criteria include procedures for this test. A detailed description of Hveem's method can be found in MS-10, Soil Manual of the Asphalt Institute, 1963. The compaction was obtained by using a kneading compactor as shown in Figure 12. Specimens are compacted by the ram of an air-hydraulic cylinder that lowers the wedge-shaped compaction foot into contact with the material, applies a predetermined pressure, dwells for a predetermined time, lifts, rotates the 4" mold and then automatically repeats the cycle. Determination of expansion pressure was omitted because of its irrelevance to this experiment. Summary of the results is given in Appendix F.

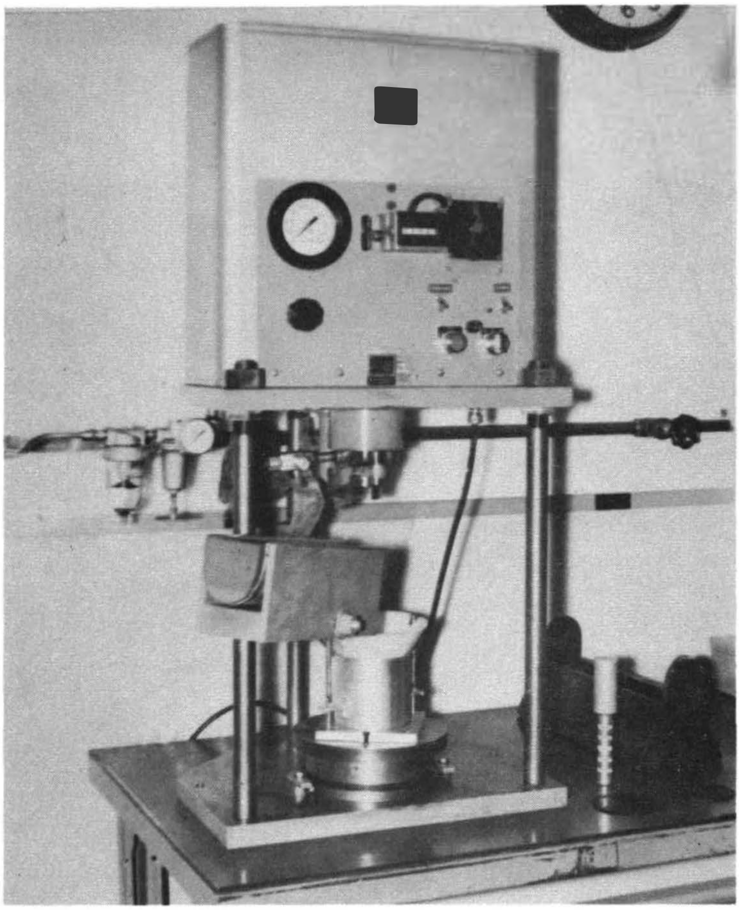


Fig. 12. Kneading Compactor

8. TRAFFIC VOLUME

Highway pavements are subjected to many different vehicle loads. Load intensities may range from less than 1000 lbs per axle to more than 40,000 lbs. Studies have shown that the effect of vehicle loads on pavements varies not only with the magnitude of the load, but with the type of pavement, thickness, subgrade condition, duration of application, location of application with respect to the pavement edge, and perhaps other factors.

In the AASHO road test, any one test section was subjected to but one weight and geometry of truck traveling at constant and identical speed. Thus, the problem of accounting for most of the above variables was obviated. Since this was impossible to do in the Oklahoma Test, reasonable account of major factors was necessary.

It is common practice, as reflected in several design procedures, to convert vehicle loads from mixed traffic to equivalent 18 kip axle loads. Such equivalents were calculated for all test sections of the Oklahoma study by utilizing traffic data from the annual Traffic Characteristics analysis published by the Oklahoma Highway Department, together with analyses of truck weights as reported in the department's annual Truck Weight Study. The method of calculation may best be described by a numerical example, taking Test Section 3 as an illustration. (See the next page.)

Data for each test section was taken from traffic count location and truck weighing stations thought to most closely reflect conditions at that test section, since no traffic records were available for actual test sites. It must also be recognized that the equivalency factors used are not weighted for variables such as season of the year, structural capacity of the pavement, etc.

TEST SECTION 3

--Percent of Total Average Daily Traffic (ADT)--

Year	Pass. Cars	Pickup	2-axle 6 Tires	3-axle	3-axle semi	4-axle	5 or more axle	ADT
1966	76.09	12.18	3.15	0.50	0.75	1.53	5.11	36,100
1967	76.09	12.22	3.92	0.42	0.66	1.05	4.88	23,900
1968	75.70	13.36	3.34	0.55	0.63	1.23	4.22	42,900

Calculated ADT

1966	27,500	4400	1140	180	270	550	1850
1967	18,200	2900	940	100	160	250	1170
1968	32,500	5700	1430	240	270	530	1810

Equivalency Factor

1966	.0004	.0048	.1921	.3182	.6089	.7111	1.0261
1967	.0004	.0040	.1512	.4305	.6046	.7187	2.4662
1968	.0004	.0030	.1242	.4002	.5653	.7477	3.8611

Equivalent 18 kip axle loads per day

								TOTAL
1966	11	21	218	57	165	392	1893	2757
1967	7	12	142	34	95	180	2876	3355
1968	13	17	178	94	153	395	6988	7838

Total Equivalents (corresponding to dates of CHLOE readings)

1966	2757 x 3 months x 30 days/month =	248,130
1967	3355 x 12 months x 30 days/month =	1,207,800
1968	7838 x 4 months x 30 days/month =	940,560
	Total 18 kip equiv. axle loads	2,396,490

Division point between "heavy" and "light" traffic was originally set for this study at 3300 vehicles per day. In terms of 18 kip axle loads at T.S. 3, a value of 3300 ADT would correspond to about 230,000 axle loads over the 19 month interval between CHLOE runs. At another rural highway, 3300 ADT might be the equivalent of 200,000 axle loads over the same period of time. While either criterion separates the test sections into two roughly equal groups, the 18 kip axle loads per time unit is somewhat more logical as a pavement-depreciating mechanism.

Total 18 kip axle equivalent loads on each pavement test section are shown in Appendix D.

9. DISCUSSION AND CONCLUSION

General

The one parameter of greatest significance in this study is that one used to measure pavement performance. The instrument selected for this important job was the CHLOE roughometer, and the developmental background of this device, as well as its operational use, has been documented earlier in this report. Its use was based on the theory that deterioration of the road structure, whether it be caused by inadequacies in the thickness or quality of pavement layers, or by climatic condition or accumulated traffic loads, is reflected in increasing roughness of the pavement surface.

During the testing period, 167 pairs of CHLOE measurements were made, including 60 locations at which measurements were made on two immediately adjoining 500 ft. sections. Of the 167 pairs, 99 indicated increased roughness of the pavement surface, and 68 showed a reduced roughness, as reflected in the present serviceability index (PSI) calculated from CHLOE reading. Average change in PSI for all 167 pairs was 0.094. For the sections showing a positive change (i.e., in the expected direction) in PSI, the average change was 0.234 units, while the sections indicating negative change averaged 0.146.

Figures 13 and 14 list all of the PSI differences recorded between successive pairs of CHLOE readings. It will be noted that for numerous combinations of the seven measured parameters, no information is available. Of the 192 possible combinations, 72 were found to exist in the Oklahoma State Highway System. In view of the number of vacancies in the tabulated data, and more especially because of the large number of readings seemingly indicating smoother rather than rougher pavement surface, it is not possible

EXPERIMENT DESIGN WITHIN ONE REGION
AASHO RESEARCH PROJECT 4334

CLIMATE REGION DRY

TRAFFIC			<300 18-KIPS EQUIVALENT AXLE-LOADS												≥300 18-KIPS EQUIVALENT AXLE-LOADS											
SURFACE THICKNESS			<2½"						2½" - 5"						<2½"						2½"-5"					
BASE TYPE			SA		BB		S		SA		BB		S		SA		BB		S		SA		BB		S	
BASE THICKNESS			≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8
SUBBASE THICKNESS	>6"	SUBGRADE CLASSIFICATION: POOR			{-.04, .31}									{[illegible], -.12}								{[illegible], [illegible]} {[illegible], .23} {.15, .16} .14	{.17, .30}	{.07, -.32}	.16	.07 .03
		GOOD	{[illegible], [illegible]}		{[illegible], [illegible]} {[illegible], [illegible]}			-.22			-.47		.08					{[illegible], .14}				{-.12, [illegible]} .13 -.11 -.08			{.04, -.03}	.003
	≤6"	POOR	{-.27, -.20} {-.01, -.14}					{[illegible], [illegible]} {[illegible], [illegible]} {[illegible], [illegible]}	{[illegible], [illegible]}		{-.13, .30}										-.27		{.47, .33}		{[illegible], [illegible]}	.30
		GOOD		{-.45, .40} {[illegible], [illegible]}	{[illegible], -.37}					{[illegible], [illegible]}		{[illegible], [illegible]}	{-.17, -.14}	{[illegible], [illegible]}								{-.02, .31} {-.26, -.23} {-.23, -.19} {-.71, -.32}	{[illegible], .17}		.37	-.14

Figure 13. Statistical Layout of PSI Differences

EXPERIMENT DESIGN WITHIN ONE REGION
AASHO RESEARCH PROJECT 4334

CLIMATE REGION WET

TRAFFIC		<300 18-KIPS EQUIVALENT AXLE-LOADS											
SURFACE THICKNESS		<2½"						2½"-5"					
BASE TYPE		SA		BB		S		SA		BB		S	
BASE THICKNESS		≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8
SUBBASE THICKNESS >6"	SUBGRADE CLASSIFICATION POOR					{.40, .63}	{.07, -.15} {.38, .08}			-.30 {.05, .75} {.20, .62}			
SUBBASE THICKNESS >6"	SUBGRADE CLASSIFICATION GOOD	{.07, .16} {-.02, -.14}	.15	-.18	{.60, .56}								
SUBBASE THICKNESS ≤6"	SUBGRADE CLASSIFICATION POOR			-.01 .19 {.09, .20} .18		{.27, .25}		{.16, .29} 1.37	{.36, .58}				
SUBBASE THICKNESS ≤6"	SUBGRADE CLASSIFICATION GOOD			.34		-.15	{.57, .09} {-.09, -.14}	{.01, .14} .42		{.13, .41} .42			

TRAFFIC		≥300 18-KIPS EQUIVALENT AXLE-LOADS											
SURFACE THICKNESS		<2½"						2½"-5"					
BASE TYPE		SA		BB		S		SA		BB		S	
BASE THICKNESS		≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8	≤8	>8
SUBBASE THICKNESS >6"	SUBGRADE CLASSIFICATION POOR							-.09	-.16	{-.16, .22}	.57 {.20, .43}	-.03	{-.07, .33}
SUBBASE THICKNESS >6"	SUBGRADE CLASSIFICATION GOOD								.28 -.09	-.36	.25	{-.18, .20} -.13	{-.004, .26}
SUBBASE THICKNESS ≤6"	SUBGRADE CLASSIFICATION POOR							.25 {.11, .34}		.22 {.09, .00}	{[illegible], .11}	.34	.22
SUBBASE THICKNESS ≤6"	SUBGRADE CLASSIFICATION GOOD							.33 .57	-.14	-.42 {-.17, -.03} .19 {[illegible], .13}	.43	.08	-.06

Figure 14. Statistical Layout of PSI Differences

to pursue a meaningfull regression analysis of the total data. It is believed, however, that information of interest may be obtainable by observation of the data in its entirety.

Table 5 presents comparisons, for both total sections measured and averages for parameter-combination blocks, of the number of cases in which change in PSI is in the positive direction (reduced PSI) vs the number in the negative direction. Keeping in mind that of 167 total sections, 99 were "positive" and 68 "negative," it may be noted that in wet vs dry areas of the state the positive to negative ratio was 60 to 24 in wet areas and 39 to 44 in dry areas. This confirms at least in a qualitative way that the highway in wetter regions may be more susceptable to damage, or that at any rate climate may be a factor deserving further investigation.

Looking at the tabulated quantities for effect of traffic, of the 72 blocks of differing parameter characteristics, the ratio of positive changes in PSI to negative was considerably lower for smaller traffic sections (19 to 14) than for heavily traveled roads (27 to 12), a not unexpected conclusion.

Further study of those blocks involving both traffic and climate reveals that for low traffic roads, ratio of positive-negative differences in PSI is 14 to 2 in wet climate and 5 to 12 in dry, whereas on heavily traveled roads the same ratios are 15 to 7 and 12 to 5. The ratios for heavy traffic are not significantly different, but in light traffic considerable difference is evident.

Study of the raw data in this admittedly crude manner leads to the observation that little significant effect is noted between thicknesses or quality of roadbed layers below the surface layers. This agrees with the results of the AASHO test wherein the influences of various pavement layers

TABLE 5

BREAKDOWN OF PSI DIFFERENCES BY PARAMETERS

Parameter	All sections measured (167) + Changes	- Changes	Total	Separate combinations (72) + Changes	- Changes	Total
Wet Region	60	24	84	29	9	38
Dry Region	39	44	83	17	17	34
Good Subgrade	43	43	86	23	16	39
Poor Subgrade	56	25	81	23	10	33
≤6" Subbase	52	40	92	23	15	38
>6" Subbase	47	28	75	23	11	34
≤8" Subbase	58	31	89	27	13	40
>8" Subbase	41	37	78	19	13	32
Sand-Asphalt Base	30	28	58	11	9	20
Black Base	42	17	59	18	7	25
Stabilized Base	27	23	50	17	10	27
<2 1/2" Surface	32	22	54	14	6	20
2 1/2 - 5 Surface	67	46	113	32	20	52
<300 18K Eq./Day	47	37	84	19	14	33
>300 18K Eq./Day	52	31	83	27	12	39

diminished with distance from the surface.

Rather than observing which sections decreased in PSI and which increased, one might use the average change as a norm, and compare individual block changes on this basis. Of the 72 blocks for which one or more CHLOE differences were recorded, the average block suffered a loss in PSI of 0.094. Of the 34 blocks with greater than average PSI differences, 23 were in wet and 11 in dry climatic areas. Of the 38 blocks with smaller than average differences, 15 were in wet and 23 in dry areas. These figures emphasize similar results noted on a positive vs negative classification.

Looking at the data in still another way, the ten blocks showing the greatest loss of performance were examined to see if any consistency could be noted in the seven parameters measured. PSI differences for the ten blocks varied from 0.61 units to 0.37 units. Seven of the ten were from high rainfall areas, and eight of the ten involved pavement surfaces greater than 2½ inches. For each of the remaining parameters there was but little difference in the number of blocks falling into each parameter level.

On the whole, it appears from admittedly superficial investigation that rainfall, traffic, and surface thickness are more influential in affecting pavement performance than are the other parameters measured. It is apparent, however, that a more searching study of the data is not possible at this juncture. The AASHO Satellite guide recommends basing conclusions on PSI differences of at least 1.0 units, whereas differences obtained to date in the Oklahoma study average 0.094 units. Readings taken over a period of seven to ten years may produce the data base desired.

Supplemental Study

In order to ascertain the degree of confidence that could be attributed to roughness measurements determined by the CHLOE procedure, several trial runs were made on selected flexible and rigid pavements. Initially, it was presumed that successive CHLOE runs could be made in practically identical paths, so that differences in roughness measurements would largely be attributable to inaccuracy in the mechanism. It was found, however, by the use of paint drippings, that a lateral excursion of several inches could not practically be avoided. It was learned, moreover, that roughness differences between successive runs were greater on flexible pavements than on rigid, leading to a belief that much of the difference on flexible pavements may be due to pavement rutting, since the slope wheels of the CHLOE are often climbing or descending the sides of the rut in attempting to follow the wheel path.

Appendix G shows the data and statistical analysis of the experiment. The tests were conducted on four sections of roadway -- two flexible and two rigid pavements -- near Shawnee, Oklahoma. Since the interest in this supplementary test was centered on the CHLOE only, no measure of cracking or patching was included in the PSI determination.

In examining the data it is apparent that greater precision in measuring serviceability index is obtainable on rigid pavements than on flexible. In addition, there is more variation between readings in the outer wheel path of flexible pavements than the inner wheel path. Rutting would of course be expected to be greater in the outer wheel path.

The confidence interval in terms of slope variance for flexible pavement No. 1, inner wheel path, as shown in Appendix G is ± 0.114 at 95% probability, and ± 0.089 at 90% probability. Converting to PSI values, this indicates that for the seven supposedly identical successive runs, PSI differences of 0.38 and 0.30 may be expected at 95% and 90% probability levels. These figures may be compared with the average of 0.94 PSI difference encountered on the 167 pairs of CHLOE readings in the main experiment.

This small experiment would seem to underscore the AASHO recommendation that differences of 1.0 in PSI are desirable in order to produce a meaningful base for distinguishing the effects of pavement variables on roadway deterioration.

Conclusion

It is the belief of the project investigators that the objectives of this experiment have a great deal of merit. Although the results fall considerably short of attaining the desired objectives, it is believed that much benefit can derive from the study, and that it would be very worthwhile to continue periodic accumulation of roughness measurements to obtain a more satisfactory data base. It seems fairly well indicated even at this stage that certain measured factors are of small significance, as indicated in the report, and that future attention might be focused on such variables as rainfall, traffic and surface characteristics.

The use of the CHLOE as the primary means for measuring pavement serviceability appears to be controversial. It may well be that the measurement of surface roughness may be too superficial a test to diagnose the condition of the whole pavement structure. Development of a more perceptive diagnostic device is entirely without the scope of this investigation. Nevertheless, it is strongly suggested that research on such a device be encouraged.

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APPENDIX A

COMPUTATION FOR PRESENT SERVICEABILITY INDEX

```
C      PRESENT SERVICEABILITY INDEX      AASHO RESEARCH PROJECT 4334
       DIMENSION DIFF(6), REA(6), SUMY(6), SUMYSQ(6)
10     FORMAT ( 3I7 )
12     FORMAT ( 6F7.0 )
30     FORMAT ( 3X, I3, 12X, I1, 12X, F7.4, 8X, F6.1, 7X, F6.1, 8X, F4.2)
111    FORMAT ( I3, 5X, 6F6.3 )
200    READ 10, NTS, NSCTS, LANW
                IF ( LANW ) 2, 1, 2
1          LANW = 12
2          ALANW = LANW
       READ 12, ( REA(I) , I=1, NSCTS )
       READ 12, ( SUMY(I) , I=1, NSCTS )
       READ 12, ( SUMYSQ(I), I=1, NSCTS )
           ANSCTS = NSCTS
           NS1 = NSCTS - 1
                DO 20  I=1, NSCTS
                DIFF(I) = SUMYSQ(I) / REA(I)
     1          - ( SUMY(I) / REA(I) ) * ( SUMY(I) / REA(I) )
20              CONTINUE
       PUNCH 111, NTS,  ( DIFF(I), I=1, NSCTS )
           SDIFF = 0.0
                DO  40 I=1, NS1, 2
40              SDIFF = SDIFF +  DIFF(I) + DIFF(I+1)
           SDIFF = SDIFF * 8.46
           SVBAR = SDIFF / ANSCTS - 3.0
       READ 12, CRACK, PATCH, RUT
           DMULT = 1000.0 / ( 500.0 * ALANW / 2.0 * ANSCTS )
           CBAR = CRACK * DMULT
           PBAR = PATCH * DMULT
           RTBAR = RUT / ( ANSCTS * 10.0 * 10.0 )
C      CONVERT NATURAL BASE TO BASE 10
           AAA = 0.4343 * LOG ( 1.0 + SVBAR )
C      VALUE OF PRESENT SERVICEABILITY INDEX
           PSI = 5.03 - 1.91 * AAA - 1.38 * RTBAR * RTBAR
     1     - 0.01 * SQRT ( CBAR + PBAR )
       PUNCH 30, NTS, NSCTS, PSI, CBAR, PBAR, RTBAR
                GO TO 200
77     CONTINUE
       STOP
       END
```

Appendix B

Data Sheet for Road Performance Evaluation

Sheet __ of __

Contract Research Project 64-11-3
Oklahoma State University

CHLOE PROFILOMETER

Pavement Serviceability Rating
For Flexible Pavement

Const. Proj. No.__________

Test Site No.__________

Sta.______ to Sta.______

County__________

Route No.__________

No. of Lanes__________

Lane Width (W)__________

Section Length (L) 500 feet

Date__________

Weather__________

Party__________ & Crew

	Slope Variance						Section	Rut Depth					
Lane*													
Dir. of Travel**													
Wheelpath***													
No. of Readings (N)							1						
ΣY							2						
ΣY^2							3						
$(\Sigma Y/N)$							4						
$(\Sigma Y^2/N)$							5						
$(\Sigma Y/N)^2$							6						
Difference							7						
SV = Diff. x 8.46							8						
Cracks* Sq. ft.							9						
Patching Sq. ft.							10						

ΣC = Cracks for Test Sec.______

ΣP = Patching for Test Sec.______

RD Totals __________

$\overline{SV} = \frac{\text{SV Totals}}{\text{No. of Sections}} - 3 =$ ______

$\frac{\Sigma C}{L \times \frac{1}{2} W \times \text{No. of Sec.}} \times 1000 =$ ____ $= \bar{C}$, $\frac{\Sigma P}{L \times \frac{1}{2} W \times \text{No. of Sec.}} \times 1000 =$ ____ $= \bar{P}$ $\quad 0.01\sqrt{\bar{C} + \bar{P}} =$ ______

$\bar{C}$ & $\bar{P}$, Sq. Ft. of cracking and patching per 1000 Sq. Ft. of pavement surface area. Cracking and patching sections 500 ft. long numbered 1 to 8 in direction of travel. Record all patches and cracks (class 2 & 3) in Sq. Ft., in the $\frac{1}{2}$ lane width traversed by the profilometer. L = length of sections, W = lane width.

$\overline{RD} = \frac{\text{AVG RD}}{10} =$ ________

Rut Depth measured in .1 of inch and recorded and treated as integers.

Pavement Serviceability Rating for Flexible Pavement $= 5.03 - 1.91 \text{ Log } (1 + \overline{SV}) - 1.38\ \overline{RD}^2 - 0.01\sqrt{\bar{C} + \bar{P}} =$ ________

* OL = Outside Lane
IL = Inside Lane
ML = Middle Lane
NB = North Bound
SB = South Bound
EB = East Bound
WB = West Bound

** S-N South-North
N-S North-South
E-W East-West
W-E West-East

*** Wheel path numbered 1, 2, 3, etc., from the outside shoulder toward C/L of construction with direction of travel.

APPENDIX C

PAVEMENT PERFORMANCE DATA

T.S.NO.	RUN	NO. OF SECTIONS	DATE	PSI	CRACK	PATCH	RUT DEPTH
3	1	6	10-12-66	3.2388	0.0	0.0	.17
3	2	6	04-16-68	3.2054	.8	0.0	.18
4	1	4	06-15-66	4.0663	0.0	0.0	.05
4	2	4	01-10-69	3.7851	0.0	0.0	.00
7	1	4	06-15-66	4.0988	0.0	0.0	.08
7	2	4	07-26-68	3.5249	0.0	0.0	.05
9	1	4	08-04-66	3.8800	0.0	0.0	.03
9	2	4	01-10-69	4.0405	0.9	0.0	.00
11	1	4	06-23-66	3.5879	0.0	0.0	.08
11	2	4	03-27-68	3.7278	0.0	0.0	.02
13	1	4	06-24-66	4.0997	0.0	0.0	.02
13	2	4	03-28-68	4.1940	0.0	0.0	.02
17	1	4	06-24-66	4.2111	0.0	0.0	.07
17	2	4	03-28-68	3.9593	0.0	0.0	.01
26	1	4	06-23-66	4.0112	0.0	0.0	.09
26	2	4	07-24-67	3.7682	0.0	0.0	.08
33	1	4	12-07-66	3.7487	0.0	0.0	.03
33	2	4	11-29-67	3.9250	0.0	0.0	.03
34	1	4	12-07-66	4.1791	0.0	0.0	.02
34	2	4	11-20-67	3.9914	0.0	0.0	.03
37	1	4	12-07-66	3.9249	0.0	0.0	.03
37	2	4	11-20-67	3.9374	0.0	0.0	.02
38	1	4	12-09-66	3.4593	18.4	0.0	.07
38	2	4	08-17-67	3.2335	0.0	32.3	.14
40	1	4	12-09-66	3.9655	0.0	7.6	.05
40	2	4	08-17-67	4.0257	0.0	.7	.08
42A	1	4	12-12-66	3.9247	0.0	0.0	.06
42A	2	4	08-16-67	3.2938	0.0	0.0	.12
42B	1	4	12-12-66	3.7381	0.0	0.0	.05
42B	2	4	08-16-67	3.2459	0.0	0.0	.09
43A	1	4	12-13-66	3.7588	0.0	2.2	.04
43A	2	4	07-30-68	3.4921	0.0	0.0	.04
43B	1	4	12-13-66	3.7813	0.0	0.0	.05
43B	2	4	07-30-68	3.5322	0.0	0.0	.10
44	1	4	01-03-67	3.5263	20.8	0.0	.18
44	2	4	11-07-67	3.5229	0.0	0.0	.12
45	1	4	01-03-67	3.9142	0.0	0.0	.10
45	2	4	11-07-67	4.0562	0.0	0.0	.12
47A	1	4	01-05-67	4.0426	0.0	0.0	.05
47A	2	4	11-17-67	3.5762	0.0	0.0	.16
47B	1	4	01-05-67	3.8581	0.0	0.0	.05
47B	2	4	11-17-67	3.3266	0.0	0.0	.15
48A	1	4	01-05-67	3.8190	0.0	0.0	.13
48A	2	4	11-17-67	3.6451	0.0	0.0	.15
48B	1	4	01-05-67	4.0191	0.0	0.0	.10
48B	2	4	11-17-67	3.5135	0.0	0.0	.17

APPENDIX C (CONTINUE)

PAVEMENT PERFORMANCE DATA

T.S.NO.	RUN	NO. OF SECTIONS	DATE	PSI	CRACK	PATCH	RUT DEPTH
50A	1	4	01-06-67	4.1517	0.0	0.0	.07
50A	2	4	11-10-67	4.3856	0.0	0.0	.10
50B	1	4	01-06-67	3.8218	0.0	0.0	.08
50B	2	4	11-10-67	4.0823	0.0	0.0	.13
51	1	4	01-06-67	4.0268	0.0	0.0	.08
51	2	4	11-10-67	4.1080	0.0	0.0	.07
57A	1	4	08-24-66	4.0496	0.0	0.0	0.00
57A	2	4	12-06-67	3.9537	0.0	0.0	0.00
57B	1	4	08-24-66	4.0961	0.0	0.0	.01
57B	2	4	12-06-67	3.8151	0.0	0.0	.02
58	1	4	08-24-66	4.0290	0.0	0.0	.01
58	2	4	12-05-67	3.8510	0.0	0.0	.07
68	1	6	11-08-66	4.3873	0.0	0.0	.07
68	2	6	12-07-67	4.0515	0.0	0.0	.02
72A	1	4	07-12-66	4.5456	0.0	0.0	.10
72A	2	4	07-24-67	4.3048	0.0	0.0	.13
72B	1	4	07-12-66	4.2161	0.0	0.0	.12
72B	2	4	07-24-67	4.1049	0.0	0.0	.09
74	1	4	07-12-66	4.4449	0.0	0.0	.05
74	2	4	09-27-67	4.2928	0.0	0.0	.08
76A	1	4	07-07-66	4.0086	0.0	0.0	.05
76A	2	4	09-27-67	3.8706	0.0	0.0	.08
76B	1	4	07-07-66	4.1211	0.0	0.0	.07
76B	2	4	09-27-67	4.1130	0.0	0.0	.06
77A	1	4	07-07-66	4.0896	0.0	0.0	.06
77A	2	4	09-27-67	3.9272	0.0	0.0	.02
77B	1	4	07-07-66	4.3037	0.0	0.0	.10
77B	2	4	09-27-67	4.0153	0.0	0.0	.05
80	1	4	07-12-66	4.3446	.2	0.0	.09
80	2	4	09-27-67	3.9292	0.0	0.0	.05
82	1	4	07-15-66	4.0695	0.0	0.0	.03
82	2	4	10-23-67	2.6939	0.0	0.0	.04
88	1	4	07-06-66	3.4845	0.0	0.0	.03
88	2	4	01-10-69	3.5725	0.4	0.0	.02
91	1	4	07-07-66	4.3537	0.0	0.0	.05
91	2	4	01-10-69	4.0225	0.0	0.0	.02
92	1	4	07-14-66	4.2702	0.0	0.0	.02
92	2	4	02-19-68	4.6272	0.0	0.0	.01
98	1	4	07-20-66	4.2383	0.0	0.0	.02
98	2	4	02-19-68	4.8159	0.0	0.0	.05
100	1	4	07-20-66	4.2525	0.0	0.0	.02
100	2	4	02-19-68	4.6740	0.0	0.0	.02
103	1	4	07-20-66	4.6872	0.0	0.0	.03
103	2	4	02-27-68	4.4669	0.0	0.0	.05

APPENDIX C (CONTINUE)

PAVEMENT PERFORMANCE DATA

T.S.NO.	RUN	NO. OF SECTIONS	DATE	PSI	CRACK	PATCH	RUT DEPTH
106A	1	4	07-13-66	4.9868	0.0	0.0	.04
106A	2	4	02-09-68	4.8756	0.0	0.0	.05
106B	1	4	07-13-66	4.8209	0.0	0.0	.05
106B	2	4	02-09-68	4.8039	0.0	0.0	.07
107	1	4	07-13-66	4.3653	0.0	0.0	.05
107	2	4	02-07-67	3.9372	0.0	0.0	.06
108A	1	4	08-08-66	4.0560	0.0	0.0	.04
108A	2	4	01-26-68	4.0395	0.0	0.0	.12
108B	1	4	08-08-66	4.2030	0.0	0.0	.02
108B	2	4	01-26-68	4.1897	0.0	0.0	.12
111A	1	4	08-09-66	3.9957	0.0	0.0	.05
111A	2	4	01-26-68	4.1617	0.0	0.0	.13
111B	1	4	08-09-66	3.7857	0.0	0.0	.04
111B	2	4	01-26-68	3.8213	0.0	0.0	.12
114	1	4	08-10-66	4.0956	0.0	0.0	.06
114	2	4	01-17-68	3.5264	0.0	0.0	.08
123	1	4	12-15-66	4.2730	0.0	0.0	.04
123	2	4	01-10-68	4.1697	0.0	0.0	.05
130A	1	4	03-15-67	3.2080	0.0	0.0	.01
130A	2	4	09-12-67	3.3593	0.0	0.0	.12
130B	1	4	03-15-67	3.4283	0.0	0.0	.02
130B	2	4	09-12-67	3.3545	0.0	0.0	.10
131A	1	4	03-15-67	3.2831	0.0	0.0	.01
131A	2	4	09-12-67	3.3716	0.0	0.0	.13
131B	1	4	03-15-67	3.2301	0.0	0.0	0.00
131B	2	4	09-12-67	3.3741	0.0	0.0	.02
135A	1	4	08-18-66	3.7960	0.0	0.0	.12
135A	2	4	08-15-67	3.4654	0.0	0.0	.11
135B	1	4	08-18-66	3.8979	0.0	0.0	.11
135B	2	4	08-15-67	3.9701	0.0	0.0	.09
136A	1	4	08-18-66	3.8008	0.0	0.0	.09
136A	2	4	08-15-67	3.7039	0.0	0.0	.10
136B	1	4	08-18-66	3.7881	0.0	0.0	.07
136B	2	4	08-15-67	3.9839	0.0	0.0	.06
137A	1	4	08-18-66	3.8737	0.0	0.0	.05
137A	2	4	08-15-67	3.6168	0.0	0.0	.05
137B	1	4	08-18-66	3.6354	0.0	0.0	.07
137B	2	4	08-15-67	3.6394	0.0	0.0	.07
145	1	4	10-12-66	4.6428	0.0	0.0	.10
145	2	4	04-17-68	4.4851	0.0	0.0	.05
151A	1	4	10-13-66	4.6142	0.0	0.0	.03
151A	2	4	04-19-68	4.4927	0.0	0.0	.01
151B	1	4	10-13-66	4.5870	0.0	0.0	.05
151B	2	4	04-19-68	4.1739	0.0	0.0	.02

APPENDIX C (CONTINUE)

PAVEMENT PERFORMANCE DATA

T.S.NO.	RUN	NO. OF SECTIONS	DATE	PSI	CRACK	PATCH	RUT DEPTH
152A	1	4	10-13-66	4.0004	0.0	0.0	.03
152A	2	4	04-19-68	3.2532	0.0	0.0	.04
152B	1	4	10-13-66	3.8507	0.0	0.0	.02
152B	2	4	04-19-68	3.7984	0.0	0.0	.04
153	1	4	10-18-66	3.9056	0.0	0.0	.06
153	2	4	04-19-68	3.4802	0.0	0.0	.05
155A	1	4	10-18-66	4.6748	0.0	0.0	.02
155A	2	4	04-19-68	4.3910	0.0	0.0	.02
155B	1	4	10-18-66	4.5612	0.0	0.0	.01
155B	2	4	04-19-68	3.9447	0.0	0.0	.02
157	1	4	01-04-67	3.8521	0.0	0.0	.09
157	2	4	07-25-67	3.7824	0.0	0.0	.04
158	1	4	01-04-67	3.4768	0.0	0.0	.15
158	2	4	07-25-67	3.5073	0.0	0.0	.09
159	1	4	01-04-67	3.7318	0.0	0.0	.09
159	2	4	07-25-67	3.6459	0.0	0.0	.12
160A	1	4	01-09-67	4.0862	0.0	0.0	.04
160A	2	4	05-20-68	3.9331	0.0	0.0	.06
160B	1	4	01-09-67	4.3491	0.0	0.0	.04
160B	2	4	05-20-68	4.1858	0.0	0.0	.06
161	1	4	01-10-67	3.9620	0.0	0.0	.06
161	2	4	05-20-68	4.0724	0.0	0.0	.05
164	1	4	01-11-67	3.9136	0.0	0.0	.03
164	2	4	05-17-68	4.1836	0.0	0.0	.06
165A	1	4	01-11-67	3.7108	0.0	0.0	.03
165A	2	4	05-20-68	3.9438	0.0	0.0	.05
165B	1	4	01-11-67	3.8249	0.0	0.0	.05
165B	2	4	05-20-68	4.0114	0.0	0.0	.10
167A	1	4	01-10-67	3.9666	0.0	0.0	.06
167A	2	4	05-20-68	4.0095	0.0	0.0	.04
167B	1	4	01-10-67	3.8764	0.0	0.0	.01
167B	2	4	05-20-68	4.2180	0.0	0.0	.06
169A	1	4	01-12-67	4.2346	0.0	0.0	.05
169A	2	4	05-17-68	4.9431	0.0	0.0	.11
169B	1	4	01-12-67	4.2063	0.0	0.0	.07
169B	2	4	05-17-68	4.5257	0.0	0.0	.15
170A	1	4	01-16-67	3.8046	0.0	0.0	.05
170A	2	4	05-22-68	3.9269	0.0	0.0	.12
170B	1	4	01-16-67	3.9462	0.0	0.0	.04
170B	2	4	05-22-68	4.0279	0.0	0.0	.11
176A	1	4	01-17-67	4.0340	0.0	0.0	.11
176A	2	4	05-27-68	3.8284	0.0	0.0	.09
176B	1	4	01-17-67	3.8296	0.0	0.0	.08
176B	2	4	05-27-68	3.9153	0.0	0.0	.07
177A	1	4	01-18-67	5.0045	0.0	0.0	.04
177A	2	4	05-27-68	4.5223	0.0	0.0	.04
177B	1	4	01-18-67	4.6370	0.0	0.0	.04
177B	2	4	05-27-68	5.0940	0.0	0.0	.03

APPENDIX C (CONTINUE)

PAVEMENT PERFORMANCE DATA

T.S.NO.	RUN	NO. OF SECTIONS	DATE	PSI	CRACK	PATCH	RUT DEPTH
179A	1	4	01-19-67	3.9041	0.0	0.0	.07
179A	2	4	05-29-68	3.9332	0.0	0.0	0.00
179B	1	4	01-19-67	3.8560	0.0	0.0	.06
179B	2	4	05-29-68	4.1288	0.0	0.0	.01
180A	1	4	03-01-67	4.4225	0.0	0.0	.06
180A	2	4	05-29-68	4.4411	0.0	0.0	0.00
180B	1	4	03-01-67	4.3498	0.0	0.0	.05
180B	2	4	05-29-68	4.4856	0.0	0.0	.02
181A	1	4	03-01-67	4.4225	0.0	0.0	.06
181A	2	4	05-29-68	4.7025	0.0	0.0	.02
181B	1	4	03-01-67	4.4749	0.0	0.0	0.00
181B	2	4	05-29-68	4.6778	0.0	0.0	.01
184A	1	4	03-02-67	4.1259	0.0	0.0	.03
184A	2	4	06-11-68	3.9133	0.0	0.0	.04
184B	1	4	03-02-67	4.2192	0.0	0.0	.03
184B	2	4	06-11-68	4.2663	0.0	0.0	.06
185A	1	4	03-02-67	4.2288	0.0	0.0	.02
185A	2	4	06-11-68	4.3918	0.0	0.0	.04
185B	1	4	03-02-67	4.5083	0.0	0.0	.03
185B	2	4	06-11-68	4.2090	0.0	0.0	.04
188A	1	4	03-08-67	3.1215	0.0	0.0	.02
188A	2	4	06-04-68	3.0918	0.0	0.0	.07
188B	1	4	03-08-67	3.0498	0.0	0.0	.04
188B	2	4	06-04-68	3.2175	0.0	0.0	.07
191A	1	4	03-08-67	3.5607	0.0	0.0	.02
191A	2	4	06-07-68	3.7658	0.0	0.0	.01
191B	1	4	03-08-67	3.4810	0.0	0.0	.04
191B	2	4	06-07-68	3.6081	0.0	0.0	.06
192	1	4	03-08-67	3.5353	0.0	0.0	.07
192	2	4	06-07-68	3.7626	0.0	0.0	.05
193A	1	4	03-08-67	3.2258	0.0	0.0	.03
193A	2	4	06-07-68	3.2045	0.0	0.0	.04
193B	1	4	03-08-67	3.3792	0.0	0.0	.02
193B	2	4	06-07-68	3.4247	0.0	0.0	.04
196A	1	4	03-10-67	3.8696	0.0	0.0	.05
196A	2	4	06-20-68	4.2827	0.0	0.0	.07
196B	1	4	03-10-67	4.0838	0.0	0.0	.04
196B	2	4	06-20-68	4.1466	0.0	0.0	.05
198A	1	4	03-10-67	4.4444	0.0	0.0	.06
198A	2	4	06-20-68	4.3418	0.0	0.0	.04
198B	1	4	03-10-67	4.2140	0.0	0.0	.06
198B	2	4	06-20-68	4.3446	0.0	0.0	.05
199	1	4	03-09-67	3.3122	0.0	0.0	.15
199	2	4	06-21-68	2.9461	0.0	0.0	.17

APPENDIX C (CONTINUE)

PAVEMENT PERFORMANCE DATA

T.S.NO.	RUN	NO. OF SECTIONS	DATE	PSI	CRACK	PATCH	RUT DEPTH
201A	1	4	03-09-67	3.5367	4.5	0.0	.17
201A	2	4	06-21-68	3.5175	0.0	0.0	.20
201B	1	4	03-09-67	3.6467	1.0	0.0	.13
201B	2	4	06-21-68	3.6336	0.0	0.0	.17
205A	1	4	03-09-67	3.1805	.8	0.0	.09
205A	2	4	06-21-68	3.2118	0.0	0.0	.15
205B	1	4	03-09-67	3.5864	1.6	0.0	.07
205B	2	4	06-21-68	3.5479	0.0	0.0	.17
206A	1	4	03-03-67	3.5752	0.0	0.0	.07
206A	2	4	06-14-68	3.7450	0.0	0.0	.08
206B	1	4	03-03-67	3.9557	0.0	0.0	.08
206B	2	4	06-14-68	4.0982	0.0	0.0	.06
207A	1	4	03-03-67	3.6153	0.0	0.0	.07
207A	2	4	06-14-68	3.7518	0.0	0.0	.08
207B	1	4	03-03-67	3.9316	0.0	0.0	.07
207B	2	4	06-14-68	4.0317	0.0	0.0	0.00
208A	1	4	03-03-67	4.1263	0.0	0.0	.07
208A	2	4	06-14-68	4.1501	0.0	0.0	.12
208B	1	4	03-03-67	4.1404	0.0	0.0	.07
208B	2	4	06-14-68	4.2602	0.0	0.0	.13
210A	1	4	09-22-66	4.1132	0.0	0.0	.13
210A	2	4	07-19-68	3.8870	0.0	0.0	.09
210B	1	4	09-22-66	3.7585	0.0	0.0	.12
210B	2	4	07-19-68	3.6728	0.0	0.0	.08
211	1	4	09-22-66	3.4768	0.0	0.0	.08
211	2	4	07-19-68	3.3428	0.0	0.0	.06
213	1	4	09-22-66	3.5063	0.0	0.0	.07
213	2	4	07-19-68	3.3610	0.0	0.0	.09
215A	1	4	07-08-66	4.3757	0.0	0.0	.09
215A	2	4	04-22-68	4.0310	0.0	0.0	.06
215B	1	4	07-08-66	4.7811	0.0	0.0	.05
215B	2	4	04-22-68	4.2030	0.0	0.0	.06
217A	1	4	08-03-66	4.7887	0.0	0.0	.01
217A	2	4	02-06-67	4.5250	0.0	0.0	.02
217B	1	4	08-03-66	4.2474	0.0	0.0	.04
217B	2	4	02-06-67	3.8172	0.0	0.0	.03
218	1	4	08-03-66	4.5157	0.0	0.0	.02
218	2	4	02-06-67	4.2665	0.0	0.0	.03
219A	1	4	08-03-66	4.9848	0.0	0.0	.03
219A	2	4	02-06-67	4.8296	0.0	0.0	.06
219B	1	4	08-04-66	4.9588	0.0	0.0	.02
219B	2	4	02-06-67	4.5679	0.0	0.0	.05
220A	1	4	08-04-66	4.0828	0.0	0.0	.02
220A	2	4	02-07-67	3.8013	0.0	0.0	.04
220B	1	4	08-04-66	3.8526	0.0	0.0	.02
220B	2	4	02-07-67	4.0150	0.0	0.0	.03

APPENDIX C (CONTINUE)

PAVEMENT PERFORMANCE DATA

T.S.NO.	RUN	NO. OF SECTIONS	DATE	PSI	CRACK	PATCH	RUT DEPTH
222A	1	4	08-10-66	3.9691	0.0	0.0	.12
222A	2	4	08-16-67	3.0824	0.0	.7	.11
222B	1	4	08-10-66	3.6571	0.0	0.0	.12
222B	2	4	08-16-67	3.1606	0.0	0.0	.10
224A	1	4	08-12-66	3.7768	0.0	0.0	.02
224A	2	4	08-16-67	3.2034	0.0	0.0	.08
224B	1	4	08-12-66	4.0884	0.0	0.0	0.00
224B	2	4	08-16-67	3.1949	0.0	0.0	.06
230	1	4	05-15-67	4.0895	0.0	0.0	.12
230	2	4	08-14-67	4.2437	0.0	0.0	.10
236A	1	4	09-07-66	4.1009	0.0	0.0	.03
236A	2	4	04-25-68	3.7891	0.0	0.0	.06
236B	1	4	09-07-66	3.8836	0.0	0.0	.03
236B	2	4	04-25-68	3.9084	0.0	0.0	.06
239A	1	4	07-25-66	4.5423	0.0	0.0	.07
239A	2	4	10-25-67	4.4793	0.0	0.0	.02
239B	1	4	07-25-66	4.1008	0.0	0.0	.04
239B	2	4	10-25-67	3.9833	0.0	0.0	.02
240A	1	4	07-25-66	4.3465	0.0	0.0	.02
240A	2	4	10-25-67	4.4379	0.0	0.0	.03
240B	1	4	07-25-66	4.2467	0.0	0.0	.04
240B	2	4	10-25-67	4.2839	0.0	0.0	.01
246A	1	4	09-06-66	3.8730	0.0	0.0	.07
246A	2	4	07-25-68	3.2762	0.0	0.0	.13
246B	1	4	09-06-66	3.9879	0.0	0.0	.09
246B	2	4	07-25-68	3.4319	0.0	0.0	.08
247	1	2	09-06-66	3.1134	0.0	0.0	.08
247	2	4	07-25-68	3.5865	0.0	0.0	.07
248A	1	4	09-06-66	3.8149	0.0	0.0	.16
248A	2	4	07-25-68	4.3219	0.0	0.0	.11
248B	1	4	09-06-66	3.8979	0.0	0.0	.17
248B	2	4	07-25-68	4.2592	0.0	0.0	.14
249A	1	4	09-02-66	4.1987	0.0	0.0	.07
249A	2	4	07-25-68	4.0542	0.0	0.0	.12
249B	1	4	09-02-66	4.4430	0.0	0.0	.08
249B	2	4	07-25-68	4.0967	0.0	0.0	.09
250A	1	4	09-02-66	3.9014	0.0	0.0	.10
250A	2	4	07-25-68	4.2290	0.0	0.0	.06
250B	1	4	09-02-66	4.1768	0.0	0.0	.09
250B	2	4	07-25-68	4.1050	0.0	0.0	.07
251A	1	4	08-29-66	3.6115	0.0	0.0	.11
251A	2	4	07-19-68	3.4521	0.0	0.0	.18
251B	1	4	08-29-66	3.8566	0.0	0.0	.14
251B	2	4	07-19-68	3.7897	0.0	0.0	.16
253	1	4	01-12-67	4.4556	0.0	0.0	.05
253	2	4	05-16-68	3.8692	0.0	0.0	.11
254A	1	4	03-13-67	3.2498	0.0	0.0	.04
254A	2	4	02-05-69	3.3648	0.0	0.0	.03
254B	1	4	03-13-67	3.0168	0.0	0.0	.03
254B	2	4	02-05-69	3.1707	0.0	0.0	.05

APPENDIX D

PRESENT SERVICEABILITY INDEX DIFFERENCES AND ACCUMULATED 18-KIPS EQUIVALENT AXLE-LOADS

T.S. NO.	1ST RUN P.S.I.	2ND RUN P.S.I.	P.S.I. DIFF.	T	TOTAL LOAD	LOAD PER DAY
3	3.2388	3.2054	.0334	19	2396919.0	4205.1
4	4.0663	3.7851	.2812	31	1291742.0	1388.9
7	4.0988	3.5249	.5749	26	984342.0	1261.9
9	3.8800	4.0405	-.1605	29	1272048.0	1462.1
11	3.5879	3.7278	-.1399	21	728576.0	1156.4
13	4.0997	4.1940	-.0943	21	728576.0	1156.4
17	4.2111	3.9593	.2518	21	728576.0	1156.4
26	4.0112	3.7682	.2430	13	26934.0	69.0
33	3.7487	3.9250	-.1763	12	31417.0	87.2
34	4.1791	3.9914	.1877	12	31417.0	87.2
37	3.9249	3.9374	-.0125	12	31417.0	87.2
38	3.4593	3.2335	.2258	9	157390.0	582.9
40	3.9655	4.0257	-.0602	9	157390.0	582.9
42	3.7381	3.2459	.4922	9	43405.0	160.7
42	3.9247	3.2938	.6309	9	43405.0	160.7
43	3.7588	3.4921	.2667	20	113657.0	189.4
43	3.7813	3.5322	.2491	20	113657.0	189.4
44	3.5263	3.5229	.0034	10	291044.0	970.1
45	3.9142	4.0562	-.1420	10	291044.0	970.1
47	4.0426	3.5762	.4664	11	250266.0	758.3
47	3.8581	3.3266	.5315	11	250266.0	758.3
48	3.8190	3.6451	.1739	11	250266.0	758.3
48	4.0191	3.5135	.5056	11	250266.0	758.3
50	4.1517	4.3856	-.2339	10	760637.0	2535.4
50	3.8218	4.0823	-.2605	10	760637.0	2535.4
51	4.0268	4.1080	-.0812	10	760637.0	2535.4
57	4.0496	3.9537	.0959	15	67732.0	150.5
57	4.0961	3.8151	.2810	15	67732.0	150.5
58	4.0290	3.8510	.1780	15	67732.0	150.5
68	4.3873	4.0515	.3358	13	60990.0	156.3
72	4.2161	4.1049	.1112	13	26934.0	69.0
72	4.5456	4.3048	.2408	13	26934.0	69.0
74	4.4449	4.2928	.1521	15	32631.0	72.5
76	4.1211	4.1130	.0081	15	30285.0	67.3
76	4.0086	3.8706	.1380	15	30285.0	67.3
77	4.0896	3.9272	.1624	15	30285.0	67.3
77	4.3037	4.0153	.2884	15	30285.0	67.3
80	4.3446	3.9292	.4154	15	61192.0	135.9
82	4.0695	2.6939	1.3756	16	38323.0	79.8
88	3.4845	3.5725	-.0880	30	1148493.0	1276.1

APPENDIX D (CONT'D)

PRESENT SERVICEABILITY INDEX DIFFERENCES AND ACCUMULATED 18-KIPS EQUIVALENT AXLE-LOADS

T.S. NO.	1ST RUN P.S.I.	2ND RUN P.S.I.	P.S.I. DIFF.	T	TOTAL LOAD	LOAD PER DAY
91	4.3537	4.0225	.3312	30	1148493.0	1276.1
92	4.2702	4.6272	-.3570	32	1243322.0	1295.1
98	4.2383	4.8159	-.5776	19	605875.0	1062.9
100	4.2525	4.6740	-.4215	19	605875.0	1062.9
103	4.6872	4.4669	.2203	19	605875.0	1062.9
106	4.8209	4.8039	.0170	19	564517.0	990.3
106	4.9868	4.8756	.1112	19	564517.0	990.3
107	4.3653	3.9372	.4281	7	102405.0	487.6
108	4.0560	4.0395	.0165	18	519975.0	962.9
108	4.2030	4.1897	.0133	18	519975.0	962.9
111	3.9957	4.1612	-.1660	18	519975.0	962.9
111	3.7857	3.8213	-.0356	18	519975.0	962.9
114	4.0956	3.5264	.5692	18	406717.0	753.1
123	4.2730	4.1697	.1033	13	317045.0	812.9
130	3.4283	3.3545	.0738	6	2287.0	12.7
130	3.2080	3.3593	-.1513	6	2287.0	12.7
131	3.2831	3.3716	-.0885	6	2287.0	12.7
131	3.2301	3.3741	-.1440	6	2287.0	12.7
135	3.8979	3.9701	-.0722	12	1326797.0	3685.5
135	3.7960	3.4654	.3306	12	1326797.0	3685.5
136	3.7881	3.9839	-.1958	12	1326797.0	3685.5
136	3.8008	3.7039	.0969	12	1326797.0	3685.5
137	3.6354	3.6394	-.0040	11	1284940.0	3893.7
137	3.8737	3.6168	.2569	11	1284940.0	3893.7
145	4.6428	4.4851	.1577	19	2744994.0	4815.7
151	4.6142	4.4927	.1215	19	118657.0	208.1
151	4.5870	4.1739	.4131	19	118657.0	208.1
152	3.8507	3.7984	.0523	19	118657.0	208.1
152	4.0004	3.2532	.7472	19	118657.0	208.1
153	3.9056	3.4802	.4254	18	116922.0	216.5
155	4.6748	4.3910	.2838	18	116922.0	216.5
155	4.5612	3.9447	.6165	18	116922.0	216.5
157	3.8521	3.7824	.0697	7	169690.0	808.0
158	3.4768	3.5073	-.0305	7	169690.0	808.0
159	3.7318	3.6459	.0859	7	169690.0	808.0
160	4.0862	3.9331	.1531	17	1144502.0	2244.1
160	4.3491	4.1858	.1633	17	1144502.0	2244.1
161	3.9620	4.0724	-.1104	17	1144502.0	2244.1
164	3.9136	4.1836	-.2700	17	1144502.0	2244.1
165	3.7108	3.9438	-.2330	17	1144502.0	2244.1
165	3.8249	4.0114	-.1865	17	1144502.0	2244.1

APPENDIX D (CONT'D)

PRESENT SERVICEABILITY INDEX DIFFERENCES AND
ACCUMULATED 18-KIPS EQUIVALENT AXLE-LOADS

T.S. NO.	1ST RUN P.S.I.	2ND RUN P.S.I.	P.S.I. DIFF.	T	TOTAL LOAD	LOAD PER DAY
167	3.9666	4.0095	-.0429	17	12564.0	24.6
167	3.8764	4.2180	-.3416	17	12564.0	24.6
169	4.2346	4.9431	-.7085	17	863892.0	1693.9
169	4.2063	4.5257	-.3194	17	863892.0	1693.9
170	3.8046	3.9269	-.1223	16	872175.0	1817.0
170	3.9462	4.0279	-.0817	16	872175.0	1817.0
176	3.8296	3.9153	-.0857	16	872175.0	1817.0
176	4.0340	3.8284	.2056	16	872175.0	1817.0
177	4.6370	5.0940	-.4570	16	110199.0	229.5
177	5.0045	4.5223	.4822	16	110199.0	229.5
179	3.9041	3.9332	-.0291	16	110199.0	229.5
179	3.8560	4.1288	-.2728	16	110199.0	229.5
180	4.4225	4.4411	-.0186	15	103815.0	230.7
180	4.3498	4.4856	-.1358	15	103815.0	230.7
181	4.4300	4.7025	-.2725	15	103815.0	230.7
181	4.4749	4.6778	-.2029	15	103815.0	230.7
184	4.2192	4.2663	-.0471	15	3776.0	8.3
184	4.1259	3.9133	.2126	15	3776.0	8.3
185	4.2288	4.3918	-.1630	15	3776.0	8.3
185	4.5083	4.2090	.2993	15	3776.0	8.3
188	3.1215	3.0918	.0297	15	1247.0	2.7
188	3.0498	3.2175	-.1677	15	1247.0	2.7
191	3.5607	3.7658	-.2051	15	1247.0	2.7
191	3.4810	3.6081	-.1271	15	1247.0	2.7
192	3.5353	3.7626	-.2273	15	1642.0	3.6
193	3.2258	3.2045	.0213	15	1642.0	3.6
193	3.3792	3.4247	-.0455	15	1642.0	3.6
196	3.8696	4.2827	-.4131	16	1944.0	4.0
196	4.0838	4.1466	-.0628	16	1944.0	4.0
198	4.2140	4.3446	-.1306	16	1944.0	4.0
198	4.4444	4.3418	.1026	16	1944.0	4.0
199	3.3122	2.9461	.3661	16	666932.0	1389.4
201	3.5367	3.5175	.0192	16	666932.0	1389.4
201	3.6467	3.6336	.0131	16	666932.0	1389.4
205	3.5864	3.5479	.0385	16	666932.0	1389.4
205	3.1805	3.2118	-.0313	16	666932.0	1389.4
206	3.5752	3.7450	-.1698	16	82515.0	171.9
206	3.9557	4.0982	-.1425	16	82515.0	171.9

APPENDIX D (CONT'D)

PRESENT SERVICEABILITY INDEX DIFFERENCES AND ACCUMULATED 18-KIPS EQUIVALENT AXLE-LOADS

T.S. NO.	1ST RUN P.S.I.	2ND RUN P.S.I.	P.S.I. DIFF.	T	TOTAL LOAD	LOAD PER DAY
207	3.6153	3.7518	-.1365	16	82515.0	171.9
207	3.9316	4.0317	-.1001	16	82515.0	171.9
208	4.1263	4.1501	-.0238	16	82515.0	171.9
208	4.1404	4.2602	-.1198	16	82515.0	171.9
210	3.7585	3.6728	.0857	22	609556.0	923.5
210	4.1132	3.8870	.2262	22	609556.0	923.5
211	3.4768	3.3428	.1340	22	609556.0	923.5
213	3.5063	3.3610	.1453	22	609556.0	923.5
215	4.3757	4.0310	.3447	22	113204.0	171.5
215	4.7811	4.2030	.5781	22	113204.0	171.5
217	4.7887	4.5250	.2637	6	97859.0	543.6
217	4.2474	3.8172	.4302	6	97859.0	543.6
218	4.5157	4.2665	.2492	6	97859.0	543.6
219	4.9588	4.5679	.3909	6	97859.0	543.6
219	4.9848	4.8296	.1552	6	97859.0	543.6
220	3.8526	4.0150	-.1624	6	97859.0	543.6
220	4.0828	3.8013	.2815	6	97859.0	543.6
222	3.6571	3.1606	.4965	13	4329.0	11.1
222	3.9691	3.0824	.8867	13	4329.0	11.1
224	3.7768	3.2034	.5734	13	4202.0	10.7
224	4.0884	3.1949	.8935	13	4202.0	10.7
230	4.0895	4.2437	-.1542	3	82211.0	913.4
236	3.8836	3.9084	-.0248	20	2097992.0	3496.6
236	4.1009	3.7891	.3118	20	2097992.0	3496.6
239	4.5423	4.4793	.0630	15	93864.0	208.5
239	4.1008	3.9833	.1125	15	93864.0	208.5
240	4.3465	4.4379	-.0914	15	93864.0	208.5
240	4.2467	4.2839	-.0372	15	93864.0	208.5
247	3.1134	3.5865	-.4731	23	58432.0	84.6
248	3.8149	4.3219	-.5070	23	1313995.0	1904.3
248	3.8979	4.2592	-.3613	23	1313995.0	1904.3
249	4.4430	4.0967	.3463	23	1508508.0	2186.2
249	4.1987	4.0542	.1445	23	1508508.0	2186.2
250	4.1768	4.1050	.0718	23	1546940.0	2241.9
250	3.9014	4.2290	-.3276	23	1546940.0	2241.9
251	3.6115	3.4521	.1594	22	S.R.	
251	3.8566	3.7897	.0669	22	S.R.	

APPENDIX D (CONT'D)

PRESENT SERVICEABILITY INDEX DIFFERENCES AND ACCUMULATED 18-KIPS EQUIVALENT AXLE-LOADS

T.S. NO.	1ST RUN P.S.I.	2ND RUN P.S.I.	P.S.I. DIFF.	T	TOTAL LOAD	LOAD PER DAY
253	4.4556	3.8692	.5864	17	830399.0	1628.2
254	3.2498	3.3648	-.1150	23	S.R.	
254	3.0168	3.1707	-.1539	23	S.R.	

NOTATION

S.R. = SERVICE ROAD (NO TRAFFIC RECORD AVAILABLE)

T = TRAFFIC LOAD APPLICATION PERIOD (IN MONTHS)

APPENDIX E

PROPERTIES OF ASPHALTIC MATERIALS

T.S.NO.	LAYER	THICKNESS (INCH)	SP. GR.	FLOW (0.01 IN)	STABILITY (POUND)
3	C	1 - 1/2	2.41	10	3181
	A	2	2.41	7	1755
6	C	1 - 5/8	2.22	9	4745
	A	3	2.25	9	4646
	SA	10	1.81	16	610
9	C	1 - 1/2	2.24	10	3961
	A	3 - 1/4	2.27	9	3288
	SA	9	2.06	14	610
11	C	1 - 1/4	2.24	10	4312
	A	3 - 3/4	2.24	17	2734
	SA	8 - 1/2	1.93	15	551
13	C	1 - 1/2	2.25	10	4309
	A	2 - 3/4	2.26	14	2817
	SA	8	1.89	15	769
17	C	1 - 1/2	2.26	13	3335
	A	3 - 3/8	2.25	12	3000
	SA	8	2.08	14	665
26	C	1 - 1/2	2.32	10	3581
	A	3	2.35	19	1550
	SA	8	1.90	17	319
33	C	1 - 5/8	2.36	11	3047
	BB	6 - 3/8	2.32	19	2029
34	C	2	2.33	13	2171
	BB	6	2.31	22	2057
37	C	1 - 3/4	2.38	7	2750
	BB	7	2.30	11	1544
38	C	2	2.29	11	2894
	A	2 - 3/4	2.38	13	4140
40	C	1 - 7/16	2.30	10	4348
	A	1 - 7/8	2.38	12	3431
42	C	1 - 1/2	2.36	8	3984
	A	2 - 1/2	2.40	12	2242
44	C	2	2.39	9	2530
	A	2	2.42	10	2111
45	C	2	2.38	8	2363
	A	2	2.42	6	1910
47	C	1 - 1/2	2.30	5	2398
	A	3	2.31	4	2008
	BB	7	2.30	6	1154
48	C	1	2.25	7	1946
	A	3	2.32	7	1068
	BB	8	.		
50	C	1 - 1/4	2.40	8	3502
	A	3	2.42	15	2752
	SA	10	2.13	22	828

APPENDIX E (CONTINUE)

PROPERTIES OF ASPHALTIC MATERIALS

T.S.NO.	LAYER	THICKNESS (INCH)	SP. GR.	FLOW (0.01 IN)	STABILITY (POUND)
51	C	1	2.40	5	4226
	A	3	2.42	7	2863
	SA	10	2.14	15	935
57	C	1 - 1/2	2.34	10	2908
	A	3	2.41	15	2728
	BB	7	2.36	16	1950
58	C	1 - 1/2	2.32	16	2557
	A	3	2.38	18	2574
	BB	7	2.30	28	1762
67	C	1 - 1/4	2.33	12	3696
	A	3	2.40	15	2862
	BB	9	2.32	16	1837
68	C	1 - 1/2	2.29	8	3687
	A	3	2.44	20	2651
	BB	7	2.24	28	1437
72	C	1 - 1/2	2.26	10	2088
	A	3	2.33	12	1868
	SA	8	1.84	23	488
74	C	1 - 1/2	2.62	12	2464
	A	3	2.30	8	2281
	SA	9	1.89	20	550
76	C	1 - 1/2	2.16	10	2672
	A	3	2.32	17	3757
	SA	8	1.86	27	375
77	C	1 - 5/8	2.13	24	2043
	A	3 - 5/8	2.23	18	3177
	SA	7 - 7/8	1.81	23	230
80	C	1 - 1/2	2.13	15	3234
	A	3	2.30	19	3015
	SA	8	1.86	23	529
82	C	1 - 5/8	2.39	12	1668
	A	1 - 7/8	2.41	20	877
	SA	8	1.86	17	478
88	C	1 - 1/8	2.28	8	5118
	A	3	2.32	7	2333
	SA	10	1.99	11	501
91	C	1 - 1/2	2.22	13	4808
	A	3 - 1/2	2.34	9	2834
	SA	8	1.92	11	588
92	C	1 - 1/4	2.25	8	3094
	A	3 - 1/4	2.26	12	1672
	BB	7	2.18	10	2089

APPENDIX E (CONTINUE)

PROPERTIES OF ASPHALTIC MATERIALS

T.S.NO.	LAYER	THICKNESS (INCH)	SP. GR.	FLOW (0.01 IN)	STABILITY (POUND)
98	C	1 - 1/4	2.51	12	3210
	A	3 - 1/2	2.11	10	1326
	BB	8	2.16	11	1399
100	C	1 - 1/4	2.26	7	3580
	A	3 - 1/4	2.17	9	1664
	BB	7	2.11	7	1543
103	C	1 - 1/2	2.35	8	3600
	A	3	2.29	14	1234
	BB	7	2.21	16	1182
106	C	1 - 3/8	2.30	12	2570
	A	3	2.16	10	1454
	BB	8 - 1/2	2.17	12	1439
107	C	1	2.29	11	2600
	A	3 - 1/2	2.25	12	1331
	BB	9	.		
108	C	1 - 1/2	2.33	13	1862
	A	3	2.44	13	1681
	BB	7	2.28	28	566
111	C	1	2.34	10	2891
	A	3 - 1/2	2.40	11	1702
	BB	7	.		
114	C	1 - 1/2	2.32	14	3609
	A	2 - 1/4	2.26	11	2862
	BB	10	2.19	19	1660
123	C	1 - 1/4	2.25	7	3086
	A	3	2.33	6	4112
	BB	6	2.24	7	2076
130	C	1 - 3/4	1.77	9	4170
131	C	1 - 3/4	2.26	6	3696
135	C	1 - 5/8	2.40	7	4550
	A	2 - 3/4	2.29	9	2154
136	C	1 - 3/4	2.38	4	5254
	A	2	2.29	4	2724
137	C	1 - 3/4	2.36	12	2424
	A	3	2.30	22	2270
145	C	1 - 3/8	2.31	9	2391
	A	4	2.41	7	2028
151	C	1 - 3/8	2.20	9	3663
	A	3	2.20	18	1950
	BB	6 - 1/2	2.25	20	2575
152	C	1	2.17	6	4670
	A	3 - 3/4	2.24	16	2271
	BB	7 - 1/4	2.26	19	2378

APPENDIX E (CONTINUE)

PROPERTIES OF ASPHALTIC MATERIALS

T.S.NO.	LAYER	THICKNESS (INCH)	SP. GR.	FLOW (0.01 IN)	STABILITY (POUND)
153	C	1 - 3/4	2.24	16	2624
	A	3	2.26	20	1808
	BB	4	2.19	17	1926
155	C	1	2.18	11	2449
	A	3	2.29	15	3201
	BB	7	.		
157	C	1 - 5/8	.	9	2252
	A	3	.	9	1790
158	C	1 - 1/4	2.37	9	2331
	A	3	2.40	7	1882
159	C	1 - 1/2	2.37	6	2424
	A	3	2.40	13	1291
160	A	4 - 3/4	2.39	9	2111
	SA	8 - 1/2	1.90	18	410
161	C	1 - 1/2	2.37	9	2363
	A	3	2.37	8	1144
	SA	12 - 3/8	1.93	17	353
164	C	1	2.38	8	3850
	A	4	2.40	11	1617
	SA	8	1.99	16	320
165	C	1 - 5/8	2.36	8	2247
	A	3	2.34	7	1250
	SA	8 - 3/4	1.89	15	457
167	C	1	2.28	13	2639
	A	3 - 1/2	2.38	8	1907
	SA	8 - 1/2	1.93	13	436
169	C	1 - 1/2	2.38	18	1445
	A	2 - 1/2	2.43	11	1456
	SA	8 - 1/2	2.04	16	392
170	C	1 - 3/8	2.43	9	3157
	A	2 - 1/2	2.40	15	2208
	SA	8 - 1/2	1.99	13	300
176	C	1	2.43	12	3700
	A	2 - 1/2	2.46	14	2735
	SA	9 - 1/2	1.98	17	436
177	C	1 - 5/8	2.37	9	2059
	SA	8 - 1/2	1.84	24	499
179	C	1 - 1/2	2.42	9	3196
	BB	5	3.40	25	3050
180	C	1 - 3/4	2.38	11	1574
	SA	6	1.97	20	582
181	C	2	2.38	10	1263
	SA	6	1.93	17	501
184	C	1 - 1/2	2.37	10	2279
	BB	5 - 3/4	2.46	16	1595

APPENDIX E (CONTINUE)

PROPERTIES OF ASPHALTIC MATERIALS

T.S.NO.	LAYER	THICKNESS (INCH)	SP. GR.	FLOW (0.01 IN)	STABILITY (POUND)
185	C	1 - 1/2	2.37	11	2424
	BB	6	2.46	19	1667
188	C	1 - 1/8	2.36	9	2730
191	C	1	2.40	7	2275
192	C	1	2.41	11	2446
193	C	1 - 1/2	2.38	11	1862
196	C	1	2.42	11	3458
	A	3	2.44	8	1729
	BB	9	2.48	13	1539
198	C	1 - 5/8	2.41	8	2666
	A	3	2.44	19	1248
	BB	5	2.38	18	915
199	C	1 - 5/8	2.38	8	3562
	A	2 - 1/2	2.42	7	1911
201	C	1 - 5/8	2.38	10	3103
	A	2 - 1/2	2.44	12	1900
205	C	1 - 1/2	2.35	10	3181
	A	3 - 1/2	2.40	9	1650
206	C	1 - 1/2	2.36	10	1757
	A	2 - 1/2	2.37	6	2154
207	C	1 - 1/8	2.33	12	4368
	A	2	2.36	7	1925
208	C	1	2.40	9	3892
	A	3	2.40	13	2125
210	C	1 - 1/4	2.36	9	3990
	A	2 - 1/2	2.41	8	3366
	SA	8 - 1/2	1.99	11	446
211	C	1 - 1/2	2.36	8	3899
	A	2	2.37	10	3210
	SA	8 - 1/4	1.99	15	360
213	C	1 - 1/4	2.37	9	4107
	A	2 - 5/8	2.41	8	3718
	SA	10	1.96	7	426
215	C	1 - 3/4	2.31	11	1934
	A	2 - 1/2	2.43	11	2200
	SA	9	1.88	8	364
217	C	2 - 1/4	2.43	10	2042
	A	3	2.40	14	1182
	BB	7 - 1/2	2.36	16	790
218	C	2	2.43	15	1968
	A	3	2.42	13	1369
	BB	7	2.35	12	769
219	C	1 - 5/8	2.44	13	2724
	A	3	2.41	11	1404
	BB	7	2.35	34	644

APPENDIX E (CONTINUE)

PROPERTIES OF ASPHALTIC MATERIALS

T.S.NO.	LAYER	THICKNESS (INCH)	SP. GR.	FLOW (0.01 IN)	STABILITY (POUND)
220	C	2	2.39	9	2478
	A	3	2.44	12	1889
	BB	7	2.38	20	872
222	C	1 - 1/4	2.27	11	2079
224	C	1 - 1/4	2.36	14	1749
230	C	1 - 3/4	2.45	16	1999
	A	2 - 3/4	2.46	13	1518
236	C	1 - 3/4	2.39	19	1497
	A	2 - 1/4	2.45	9	1667
	SA	10 - 1/2	2.07	13	316
239	C	2	2.39	10	1560
	SA	8 - 3/4	2.09	8	1544
240	C	2 - 1/4	2.40	7	1560
	SA	7 - 1/2	2.09	6	1217
246	C	1 - 1/2	2.36	10	2752
	SA	6 - 1/2	2.39	9	1543
247	C	1 - 3/4	2.36	6	1469
	A	3	2.31	7	998
	BB	7	2.31	8	697
248	C	1 - 1/2	2.38	7	1798
	A	3	2.43	7	1404
	BB	6	2.37	9	1181
249	C	1 - 1/2	2.35	6	3869
	BB	12	2.39	7	1468
250	C	1 - 1/2	2.30	8	2585
	A	3	2.30	9	1500
	BB	9 - 1/2	2.34	11	686
251	C	2 - 1/4	2.35	11	3129
	SA	6 - 3/4	1.97	12	490
253	C	1 - 1/4	2.40	7	3822
	A	2 - 1/2	2.42	9	1935
254	C	3/4	2.26	12	2558

NOTATION

- C - TYPE C SURFACE LAYER
- A - TYPE A SURFACE LAYER
- SA - SAND ASPHALT BASE
- BB - BLACK BASE

APPENDIX F-1

PROPERTIES OF BASE MATERIAL

T.S. NO.	THICK-NESS	SIEVE ANALYSIS PERCENTAGE PASSING 1-1/2	3/4	3/8	4	10	40	200	FIELD DEN	FIELD MOIS	R VALUE
3	14-5/8	100	86	65	52	45	29	13	156	5	56
33	8-1/4	95	69	47	34	23	14	8	149	4	66
40	9-3/4	100	100	78	58	42	25	16	148	0	68
42	7-1/4	100	91	67	48	33	20	13	145	0	77
43	6-1/2	100	91	69	55	41	28	14	149	3	85
44	11-1/8	100	86	55	47	40	19	16	144	2	80
45	9-3/8	100	83	61	53	44	20	6	149	2	80
130	9-5/8	95	70	52	41	36	29	8	144	3	78
131	10-1/8	100	100	79	63	56	46	14	141	4	80
135	9-1/2	100	92	72	59	50	35	14	125	18	66
136	7-3/4	100	88	74	61	50	32	13	129	0	64
137	10-1/4	100	87	69	54	44	29	13	148	0	79
145	6-3/4	100	92	78	63	54	27	8	143	4	78
157	8-3/4	100	100	75	61	56	36	14	154	2	45
158	7-5/8	100	100	71	55	49	32	14	153	3	44
159	7-1/4	91	69	42	31	26	18	9	142	0	42
188	9-3/4	100	67	36	28	19	9	5	138	2	83
189	6-5/8	100	75	44	38	28	13	7	136	3	82
191	8-1/4	100	88	69	58	38	15	8	147	3	84
192	10	100	88	70	61	39	14	6	137	3	84
193	9-1/4	100	83	64	57	42	17	9	133	11	79
199	8	100	90	85	78	67	32	14	141	6	54
201	6	100	90	77	68	58	33	17	110	8	54
205	7	100	89	68	59	54	47	24	146	6	54
206	7	96	64	50	43	35	29	21	151	6	46
207	13-3/8	100	72	57	50	43	37	23	147	7	68
208	9-3/4	84	67	66	65	65	62	27	146	6	65
222	14	100	67	42	32	27	23	8	129	0	76
224	9-3/8	100	79	56	44	37	32	11	132	0	80
228	5-3/8	100	85	60	48	36	25	15	133	0	74
230	4-1/2	85	67	56	47	41	34	12	0	0	63
253	13-1/4	100	74	51	44	40	28	11	148	6	76
254	7	100	81	64	50	41	23	11	145	4	40

APPENDIX F-2

PROPERTIES OF SUBBASE MATERIAL

T.S. NO.	THICK-NESS	L.L.	P.I.	SIEVE ANAL. PERCENTAGE PASSING NO.			FIELD		MAX.	OP.	R
				10	40	200	DEN	MOIS	DEN	MOIS	VALUE
3	8-1/8		NP	98	92	61	119	15			36
4	6-1/2		NP	98	63	12	119	7	118	9	70
9	7-1/8		NP	95	55	13	124	6	127	9	69
11	5-3/4		NP	91	43	9	128	8	118	10	72
13	8-5/8		NP	73	40	12	132	8	121	10	74
17	5-1/4		NP	77	45	10	120	4	117	12	74
25	5-3/4	25	10	100	98	48	114		113	13	27
33	7-1/8		NP	100	98	26	119	11	115	14	72
34	6-1/8		NP	100	99	25	116	8	112	11	73
37	5-7/8		NP	100	98	26	117	14	116	14	65
38	4-3/8		NP	100	100	31	112	17	111	13	60
40	5-3/4	29	12				114		112	10	20
42	6		NP	100	99	35	124	10	120	11	66
44	10-1/8		NP	97	93	23			118	14	63
47	5-3/4		NP	100	95	38	112	8	111	12	63
48	9-1/2		NP	98	93	32	120	12	114	11	73
50	6		NP	86	28	7	142	4	128	8	70
51	6-3/4		NP	90	40	20	136	5	130	14	68
57			NP	100	100	38		11	109	14	72
58			NP	100	100	39	116	11	108	15	68
72			NP	100	98	27	109	6	118	13	66
74	7-1/2		NP	100	98	43	126	7			36
77	6		NP	100	99	39			119	11	30
88	7-1/4		NP	94	64	11	127	5	120	9	68
92	6-1/2		NP	97	47	9	126	9	120	10	72
93			NP	97	41	13	126	10	118	11	71
100	5-5/8		NP	84	45	8	122	11	118	12	72
103	5-1/2		NP	79	42	13			122	10	76
114	7-3/4		NP	100	70	23	119	12	111	12	79
123	5-1/8		NP	100	100	27	127	7	116	12	75
130	9-1/2	19	0	100	98	50	115		112	12	62
131	5-1/2		NP	52	42	12	131	5	120	9	70
135	10-1/2		NP				114	10	108	9	66
136	11-3/4		NP				114		112	11	64
137	13-1/4		NP						116	13	68

APPENDIX F-2 (CONT'D)

PROPERTIES OF SUBBASE MATERIAL

T.S. NO.	THICK-NESS	L.L.	P.I.	SIEVE ANAL. PERCENTAGE PASSING NO. 10	40	200	FIELD DEN	FIELD MOIS	MAX. DEN	OP. MOIS	R VALUE
145	6		NP	100	94	37	125	12	119	11	70
152	8		NP	100	100	22	116	16	106	13	72
155	7-5/8		NP	100	100	29	122	12	113	10	69
157	7-1/8	20	1				120	7	118	14	32
158	4-3/8	20	4	100	99	32	113	9	112	16	57
159	5-1/2	27	11	100	100	37	108	9	113	14	36
160	12-1/2		NP	72	35	5	131	4	0	0	76
161	11-1/4		NP	78	43	7	131	9	118	10	72
164	4		NP	87	58	8	124	7	112	8	75
169	5		NP	78	45	12	125	5	120	8	76
170	16		NP	100	91	47	109	9	121	11	40
176	16-1/4		NP	100	89	37	123	9	122	11	53
179			NP	100	98	25	110	7	114	12	64
180	12		NP	100	94	40	128	6	120	11	28
181	5-5/8		NP	99	89	38	122	7	119	12	37
184	6-1/2		NP	78	26	8	133	4			80
185	7		NP	82	30	15	117	18			84
188	5-3/4		NP	96	81	32	118	14	115	14	41
191	6		NP	69	32	18	125	8	130	8	74
192	7-1/8		NP	65	29	19	132	7	129	9	72
193	5-3/4		NP	62	27	16	133	4	132	9	78
201	6		NP	100	99	37	118	12	111	11	67
205	8		NP	100	100	56	119	15	111	11	17
208	9-1/8		NP	100	100	33	119	10	110	11	68
210	13		NP	100	95	39	117	11	118	12	68
211	12		NP						119	10	27
213	8-1/2		NP						120	10	62
217			NP	90	33	10	132	9	124	10	74
220			NP	87	24	7	127	8	123	10	75
222	18-3/4		NP	100	95	12	119	8	108	10	69
224			NP						121	12	52
230	9-1/4		NP	98	96	35	122	9			41
246	13		NP								24
247	8-1/2		NP	100	98	35	117	11	114	10	69
248	9		NP						116	10	58
249	14-1/2		NP								62
250	13		NP						112	11	68
251	9-1/2		NP	99	95	36	112	13	118	12	24

APPENDIX F-3

PROPERTIES OF SUBGRADE MATERIAL

T.S. NO.	SOIL CLASS.	L.L.	P.I.	SIEVE ANAL. PERCENTAGE PASSING NO. 10	40	200	FIELD DEN	FIELD MOIS	MAX. DEN	OP. MOIS	R VALUE
3			NP	100	98	70	126	16			11
4	A -4(0)	20	4	100	100	33					60
7	A -6(2)	21	3	100	83	35	116	16	122	12	21
9	A -6(10)	19	2	100	93	48	125	13	124	11	30
11	A-2-4(0)		NP	100	96	22	120	7			65
13	A-7-6(13)	22	7	100	98	48	116	16	116	14	8
17	A-7-6(11)	30	12	100	99	63	120	12	117	16	5
26	A -6(11)	36	19	100	98	58	102		114	15	12
33	A -4(7)		NP	95	73	34	124	13	112	17	54
34	A-7-6(11)	44	13	93	81	45	111	17	104	19	33
37	A-7-6(13)	38	17	96	76	36	109	19	102	19	7
38	A-7-5(12)	69	36	98	81	44	87	33	86	29	12
40	A -4(8)	40	22	100	99	82	113		111	15	8
42	A-7-6(13)	46	24	98	83	58	113		105	17	6
43	A-7-6(16)	40	19	100	99	63	115	19	110	17	14
44	A-2-3(0)		NP	99	96	19	120	6	113	13	69
45	A -4(8)		NP	100	97	22	120	9	116	12	63
47	A-7-6(12)	44	24	97	96	17	107	19	101	21	5
48	A-7-6(14)	49	12	97	89	65	108	18	100	21	5
50	A -4(2)	20	13	96	86	4	131	10	119	11	31
51	A-7-6(9)		NP	91	86	48	124	11	116	12	48
57	A-7-6(12)	32	8	84	61	27		17	107	16	58
58		32	10	77	53	26	118	15	112	16	44
72	A -6(11)	41	30	99	95	68			112	15	5
74	A -4(2)	29	8	100	94	36	119	10	117	13	11
76	A -4(5)		NP	100	99	25	118	6	117	13	68
77	A -6(12)		NP	100	99	47	116	6	112	13	70
80	A -4(5)	32	19	100	96	58	115	16	115	18	5
82	A-7-6(11)	45	24	99	97	74	116	17	110	16	5
88	A -4(0)		NP	98	91	32	122	9	124	10	60
91	A -2(0)		NP	100	97	40	118	9	119	14	46
92	A -2(0)	20	6	97	95	48	117	17	113	14	18
98	A -6(11)	23	9	99	97	47			117	12	32
100	A -4(5)	19	7	100	98	51	121	14	118	12	34
103	A-7-6(12)	32	18	100	98	77	114	19	112	16	5
106	A -4(8)	30	9	100	92	48	105	21			36
107	A-7-6(14)	36	16	100	97	62	108	19			18

APPENDIX F-3 (CONTINUE)

PROPERTIES OF SUBGRADE MATERIAL

T.S. NO.	SOIL CLASS.	L.L.	P.I.	SIEVE ANAL. PERCENTAGE PASSING NO. 10	40	200	FIELD DEN	FIELD MOIS	MAX. DEN	OP. MOIS	R VALUE
108	A-7-6(11)		NP	78	73	48	123	8	107	14	74
111	A-2-3(0)		NP				121	8			66
114	A-7-5(18)	34	16	85	83	19	118	16	117	14	10
123	A -4(7)	32	10	62	44	30	124	14	113	16	7
130	A-7-6(11)	23	3	81	73	29	118	15	112	16	37
131	A -4(1)	28	11	53	42	24	129	10	114	13	46
135	A -4(8)	24	6	100	99	63	123	13	116	13	30
136	A -4(8)	26	11	100	99	54	136				18
137	A -4(2)	28	12	100	99	64	121	13	114	13	20
145	A -4(8)	43	22	100	98	92	111	19			5
151	A-2-3(0)		NP	100	100	25	114	11	115	12	64
152	A-7-6(13)	23	4	100	100	53	138	27	120	12	12
153	A -4(4)		NP				119	7	115	11	65
155	A-7-6(13)		NP	100	100	38	119	15	120	12	13
158	A-7-6(14)	37	17	98	95	56	112	16	109	18	5
159	A -4(1)	24	8	86	73	56	114	8	118	14	70
160	A-7-6(16)	31	9	100	100	100	114	18	108	19	6
161	A-7-6(16)	38	17	100	93	78	112	19	110	18	5
164	A-7-6(13)	60	41	100	100	86	114	18	111	17	5
165	A -4(8)		NP	100	99	34	117	8	118	11	65
167		36	23	100	99	75	117	12	109	16	7
169		22	8	99	98	60	116	15	118	12	35
170	A -4(8)	37	10	100	100	100	113	9	107	15	10
176	A -4(8)	29	13	100	100	77	115	12	115	14	16
177	A -4(5)	24	11	100	100	100	125	10	114	15	18
179			NP	100	99	21	103	13	115	12	65
180	A -4(8)	23	10	100	100	72	116	15	113	15	15
181	A-7-6(10)	29	7	100	100	64	118	9	116	13	26
184	A-7-6(14)	34	9	100	99	83	106	22	113	20	29
185	A -6(10)	32	12	100	100	100	103	17			5
188	A-7-6(15)	34	19	99	97	87	107	21	105	18	5
191	A-7-6(9)	27	13	63	57	57	114	11	111	15	18
192	A -4(5)	28	4	91	85	65	115	18	114	13	33
193	A-7-6(10)	34	12	99	89	74	111	18	108	21	6
196	A-2-3(0)		NP	100	98	17	109	7	114	12	61

APPENDIX G

Results of Special CHLOE Study

Site		Slope Variance							Coefficient of Variation %
Flexible Pavement #1	IWP	.831	.761	.483	.743	.741	.761	.862	16.6
	OWP	.492	.400	.625	.684				23.2
Flexible Pavement #2	IWP	.710	.936	.640	.652	.607	.558		19.6
	OWP	.577	.400	.397	.462				16.0
Rigid Pavement #1	IWP	1.206	1.053	1.176	1.059	1.206	1.003		8.0
	OWP	.959	1.001	.997	1.206	.984			10.0
Rigid Pavement #2	IWP	1.269	1.181	1.355	1.294				5.7
	OWP	1.058	.982	1.006	.905				6.4

Computation of Confidence Intervals For Slope Variance

Test Site		Number of Runs	Average $\overline{SV}$	Standard Deviation	Std. Error of Mean	CI at P = 0.90	CI at P = 0.95
Flexible Pavement #1	IWP	7	0.740	0.123	0.0466	± 0.089	± 0.114
	OWP	4	0.550	0.128	0.0640	± 0.150	± 0.204
Flexible Pavement #2	IWP	6	0.683	0.133	0.0543	± 0.109	± 0.145
	OWP	4	0.479	0.074	0.0370	± 0.087	± 0.118
Rigid Pavement #1	IWP	6	1.117	0.089	0.0364	± 0.073	± 0.094
	OWP	5	1.029	0.100	0.0446	± 0.095	± 0.124
Rigid Pavement #2	IWP	4	1.275	0.072	0.036	± 0.085	± 0.115
	OWP	4	0.988	0.064	0.032	± 0.075	± 0.102

NOTE: IWP = Inside wheel path

OWP = Outside wheel path

CI = Confidence Interval

$\overline{SV}$ = Slope variance